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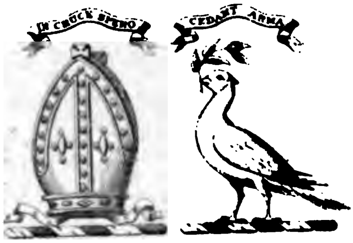

Francis Hubert Barclay

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

VOLUME THE FOURTH.

FEBRUARY, 1874,—JULY, 1876.

EDITED BY J. LOGAN LOBLEY, F.G.S.

(Authors alone are responsible for the opinions and facts stated in their respective Papers.)

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PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

ADDRESS

AT THE OPENING OF THE SESSION 1874-75.

November 6th, 1874.

BY THE PRESIDENT,

HENRY WOODWARD, ESQ., F.R.S., F.G.S., &c.

It is with no small degree of pleasure that, at the commencement of a new session, I am again permitted the honour to address you from this chair. For, though months and years are periods of which, as geologists, we can take but little heed, we are forcibly reminded by passing events that we are but ephemera; and even when regarded, not as individuals, but as a race, belonging merely to the very latest epoch of time.

Nevertheless, the more civilised of mankind, especially geologists, are by no means satisfied with the Epicurean doctrine, "Let us eat and drink, for to-morrow we die." Man's intellect, once aroused and awakened from the torpid state of mere animal existence, seeks to rise above the barriers by which he is hemmed in, and with straining gaze, looks backwards into the misty regions of the far-off past, or, though dazzled by the glare, would even strive to penetrate the veil and gaze along the vista of futurity.

Be it ours to achieve the possible, and labouring diligently, and with patience, as heretofore, to unravel the past by the light of the present, go forwards hopefully into the future with firm and unwavering steps.

Standing as "look-out" in the "fore top" of our bark, it is my duty to inform you, from time to time, what points of interest come in view, as we voyage in association onwards. Nay, I may even venture, perhaps, to warn you against pursuing certain courses which seem inviting, but are really too shallow for us to adopt; or, I may cry out, and not without reason, "Icebergs ahead!"—for if ever there was a period in the geological sea when ice was more rampant than at any other, it is certainly at the present time. One might verily believe that "the Great Ice Age" (about which Mr. James Geikie has written so eloquently) had commenced again in good earnest.

I would not have you suppose, from these remarks, that I am unwilling to admit the Ice King to be a most powerful geological agent. No one can doubt his might, or that he has left his mark on mountain, hill, and valley. But after all he is only a demi-god, to whom, with other meteoric agents, has been relegated the task of rounding and wearing down the features of our earth; but the main lines of those features were there before the Ice-King came.

To borrow from heathen mythology:—

When Vulcan, by the labours of the Cyclops, had lifted Earth above the reach of Neptune's chariot, Phœbus beheld the newly-risen lands, and scorched them with his burning gaze. Then, pitying her fate, Jupiter Pluvius descended in mist and showers, furrowing Earth's surface and hiding her form beneath an ever-green mantle, which, though rudely torn by Boreas, still encircles her.

Many of the views originally put forward by Ramsay, Jukes, Geikie, and others, on Denudation as well as Glaciation, have been strenuously opposed for years, but after passing through the fire of criticism, they have, in a more or less modified form, been admitted as Articles of Geological Faith.

But the days of our geological warfare are not yet ended!

Even so recently as the present year, the sounds of broadsword and claymore have been plainly audible, and Highlander and Lowlander have measured weapons and laid on with a will in the geological cause; the Highlander in this case being the more polished swordsman, whilst the Lowlander's strokes have much more resembled those of the redoubted Roderick Dhu;—not that we would predict such a reversal of the issue of the fight in this case, but would only deprecate such a rough style of hacking at a noble foe, and especially one whom Professor Geikie says he is anxious to secure as an ally for the "Younger School of Geologists."[*]

Mr. Kinahan's recent papers in the "Geological Magazine" and elsewhere, together with his larger Book on "Faults and Fissures and their relation to the origin of our Valleys and Lakes" [now in the press], will doubtless have a wholesome tendency on geological thought, and prevent the student from rushing wildly into *extreme views* as to the causes in operation affecting the physical features of our earth. He will be led to reflect that the same subterranean forces by whose aid the land was originally lifted above the sea have also influenced the direction of those lines of weak resistance along which the denuding forces have subsequently operated, although by attrition and denudation some of the original lines may have been rubbed out.

In reviewing the theories recently put forward to explain the Glacial Epoch, I would desire to pay a tribute of well-deserved respect to Mr. James Croll, who has devoted so many years to the task of solving these problems by the aid of rigorous and exact mathematical calculations.

It would be beyond the scope of this Address to give a full account of Mr. Croll's labours, but his most recent paper "On the Submergence and Emergence of Land during the Glacial Epoch"[*] deserves some notice here.

Starting with the proposition that a sheet of ice upon a level surface will be to all intents and purposes in a state of rest, and

FIG. 1.—Section across Antarctic Ice-cap, drawn to a natural scale.
Length represented by section = 2,800 miles. Thickness at centre (South Pole) = 12 miles.
Slope of upper surface = half-degree.

(Copied from Mr. James Croll's paper in the Geological Magazine, 1874. Decade II., Vol. I., July No., p. 307.)

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[*] See Professor Geikie's Address to the Edinburgh Geological Society, 6th November, 1873, published 1874; being a reply to the Duke of Argyll's papers and Address, Quart. Journ. Geol. Soc. Lond. 1868, and subsequently.

that therefore, for a mass of continental ice to be set in motion, there must be a piling up of ice in the interior; or, in other words, the ice-sheet must thicken from the edge inwards: and following Hopkins, Mr. Croll proceeds to point out that ice barely moves on a slope of one degree.

Assuming, therefore, for the South Polar Continent a diameter of 2,800 miles—that is to say, from the Pole to 70° S. latitude—or 1,400 miles from the centre to the circumference; a slope of one degree would give 24 miles as the thickness of the ice at the South Pole. *(See woodcut, Fig. 1.)* But, for the sake of argument, Mr. Croll reduces his estimate of the Ice-cap to a slope of a quarter of a degree, or six miles in thickness at the South Pole, with a mean thickness of two miles.

"Is there," Mr. Croll asks, "any well-grounded reason for concluding the above to be an over-estimate of the thickness of the Antarctic ice?"

[In order to put this still more clearly before my readers, I subjoin a diagram of the earth upon which a dark line at the South Pole represents, to *true scale*, an ice cap 80 miles in thickness! (See Fig. 2.)]

FIG. 2.

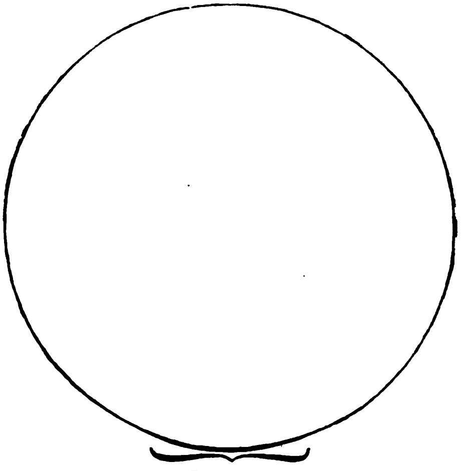


FIG 2.—Diagram to illustrate the relative proportion of the South Polar Ice-cap to the mass of the entire globe. The Ice-cap is here represented as nearly 13⅓ times as thick as Mr. Croll has estimated it to be. It would require an enormously large diagram to show, in an appreciable manner, an Ice-cap only six miles in thickness.

From the explorations of Dr. Rink, Dr. Hayes, and Professor Nordenskiöld in Greenland, we know that the ice is actually from 2,000 to 3,000 feet in thickness, and that "the inland ice continued constantly to rise towards the interior." Dr. Hayes informs us, that he and his party attained to an altitude of 5,000 feet at 70 miles from the coast, and found themselves "in the midst of a vast frozen Sahara immeasurable to the eye." Assuming for the interior a gradual continuity of the same slope as that recorded by these separate observers, this would give a height of 15,000 feet above the sea-level at the centre of dispersion of the ice in Greenland. Taking the land at 5,000 (a height which Croll, however, thinks improbable), this would still give us 10,000 feet for the thickness of the central ice.

If, then, the Continental ice in Greenland attains this thickness—and its thickness depends on the relative diameter of its area—*à fortiori*, the ice on the Antarctic land must be thicker, for the South Polar Continent is at least a dozen times greater in extent than Greenland, and its *area for evaporation* far larger.

We have evidence of this in the superior magnitude of the Antarctic icebergs. To a number of bergs, recorded by ships as having been seen and measured, Mr. Croll applies the well-known principle as to the density of ice compared with sea-water, and that every foot of ice above water represents 8·7 feet below water. These bergs were therefore from 3,880 to 9,312 feet thick, or *upwards of a mile and three-quarters!* In an extreme period this ice-sheet would, Mr. Croll assumes, be much thicker.

Applying the ice-sheet theory to North America, Professor Dana estimates the ice in the Glacial Epoch to have covered New England to a depth of 6,500 feet, or considerably over a mile; whilst for the Canadian watershed he assumes a thickness of not less than 12,000 feet, or upwards of two miles and a quarter.

Mr. Croll thinks it is not necessary to assume a largely increased quantity of ice on the globe for the Glacial Epoch above that which exists at the present time. But as Mr. Croll's theory of glacial Epochs is based on the assumption of an extreme of temperature at one or other Pole, it is, he concludes, only necessary to transfer two miles of ice off the Antarctic regions and place it on the northern hemisphere, in addition to that which now exists there, when we should in all probability be as effectually annihilated as if we had been actually in the Glacial Epoch; "at least, before it reached its maximum of severity." The bare idea of such a state of things is quite "enough to make one's blood run cold," and we instinctively stir up the fire and put some more coals on, regardless of the present price of 'Wallsend.'

The main feature in Mr. Croll's latest theory is, that by the melting of the Antarctic ice and the increment of that at the North Pole, we should have a displacement of the earth's centre of gravity, and a corresponding rise in the sea-level in our northern hemisphere. (See the subjoined Diagrams, Figs. 3 and 4, copied from Mr. Croll's paper.)

FIG. 3.

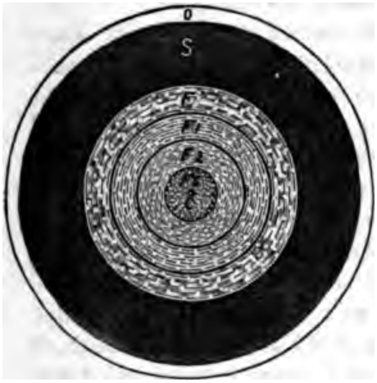
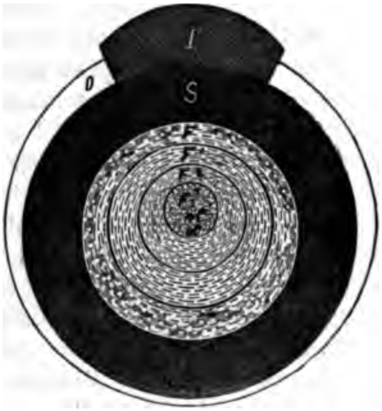


FIG. 4.



(Copied from Mr. James Croll's paper in Geological Magazine, 1874, Decade II, Vol. I, August No., p. 352.)

O. The Ocean. S. Solid Crust or Shell.

F, F^1, F^2, F^3. The various concentric layers of the fluid interior. The layers increase in density towards the centre.

I. The Ice-cap. C. The centre of gravity.

C^1. The displaced centre of gravity.

["In Figure 3, where there is no Ice-cap, the centre of gravity of the earth coincides with the centre of the concentric layers of the fluid interior." "In Figure 4, where there is an Ice-cap placed on one pole, the concentric layer F^1, being denser than layer F, is attracted towards the cap more forcibly than F, and consequently sinks to a certain depth into F." "Again F^2, being denser than F^1, it also sinks to a certain extent into F^1. And again F^3, the mass at the centre, being denser than F^2, it also sinks into F^2. All this being combined with the effects of the Ice-cap, and the displaced ocean outside the shell, the centre of gravity of the entire globe will no longer be at C, but at C^1, a considerable distance nearer to the side of the shell on which the cap rests than C, and also a considerable distance nearer than it would have been had the interior of the globe been solid."—James Croll, op. cit., p. 352.]

Mr. Croll thus places his argument before us:—"The Antarctic ice-cap is equal in area to 1-23·46 of that covered by the ocean The density of ice to that of water being taken at ·92 to 1, it follows that 25 feet 6 inches of ice melted off the cap would raise the general level of the ocean one foot, and that one mile melted off would raise the level 200 feet. To this 200 feet rise resulting from the melted ice we must add the rise resulting from the displacement of the earth's centre of gravity. The removal of the two miles of ice from the Antarctic Continent would displace the centre of gravity 190 feet, and the formation of a mass of ice, equal to one-half of this, on the Arctic regions, would carry the centre of gravity 95 feet further; giving in all a total displacement of 285 feet, thus producing a rise of sea-level at the North Pole of 285 feet, and in the latitude of Edinburgh of 234 feet. Add to this the rise of 200 feet resulting from the melted ice, and we have then 485 feet of submergence at the Pole, and 484 feet in the latitude of Edinburgh.

"A rise to a similar extent might probably take place after the period of maximum glaciation, when the ice would be melting on the northern hemisphere more rapidly than it would be forming on the southern.

"Assuming the Ice-cap to be six miles in thickness, the extent of submergence would be proportionably increased, and we might have a rise of the sea in the latitude of Edinburgh of 800 or 1,000 feet. It is clear, then, that the quantity of ice on the Antarctic Pole is perfectly sufficient to account for the submergence of the Glacial Epoch, for the general submergence did not much exceed 400 or 500 feet.

"In certain places there is evidence of from 1,000 to 2,000 feet submergence, but these may be quite local, resulting from subsidence of the land in those particular areas, elevations and depressions of land having taken place in all ages, and no doubt during the Glacial Epoch also.

"If, then," says Mr. Croll, "we admit that an increase in the eccentricity of the earth's orbit was the cause of the Glacial Epoch, then we must admit that all those results followed as necessary consequences. For if the Glacial Epoch lasted for upwards of one hundred thousand years or so, there would be a succession of cold and warm periods, and consequently a succession of elevation and depressions of sea-level. And the elevations of the sea-level would take place during the cold periods, and the depressions during the warm periods."

Mr. Croll further points out that assuming the nucleus of the earth to be fluid, surrounded by a thick and rigid crust, a further displacement of the centre of gravity would take place by the re-arrangement of the heavier and denser materials in the earth's fluid interior; the heavier materials being attracted by the Ice-cap more forcibly than the lighter, consequently they will approach towards the cap to a certain extent, thus further tending to shift the earth's centre of gravity in the direction of the Ice-cap. (See *supra*, Fig. 4.)

Mr. Croll concludes that "if we knew the extent of the general submergence during the Glacial Period, and the present amount of ice on the southern hemisphere, we could determine whether or not the earth is fluid in the interior." [*Geol. Mag.* 1874, Decade II., Vol. I., p. 353.]

In a recent paper communicated to the "Philosophical Magazine" for September, 1874, p. 218, Mr. Tylor writes—"Some geological difficulties might be explained by periodic changes of position of part of the interior of the earth."

"Also the quantity of water in the ocean can only be the difference between that of the vapour held in the atmosphere or condensed into snow or ice on the land, and the quantity of water, or vapour of water, mechanically or chemically combined with the strata of the earth. These are quantities capable of *enormous* variation in geological periods under different conditions."

Mr. Tylor believes that the theory he advanced in 1853, as to the inconstancy of rainfall and the fluctuations of the level of the sea in past geological periods, is gaining ground.

But perhaps the most elaborate essay on this subject is that by Mr. Thomas Belt, F.G.S., entitled "An examination of the Theories that have been proposed to account for the climate of the Glacial Period," which appeared in the "Quarterly Journal of Science" for October last. The outline of these views was given by him in a most interesting book, entitled "The Naturalist in Nicaragua," published in the early part of the present year.

After reading Mr. Belt's views, as propounded by him in his "Naturalist in Nicaragua," in March last, I wrote as follows:*

---

* See Geol. Mag. April, 1874, Decade II., Vol. I., p. 183.

"The present day is one of surprises and startling propositions, and it cannot be denied that in the progress of scientific research and discovery, many of our pre-conceived and long-cherished notions have been swept clean overboard. It may be that the ideas propounded by the author shall hereafter become a part of the geological principles of a future day; but will the astronomer and mathematician allow as feasible, under any circumstances, the notion of an ice-cap 8,000 feet or more in thickness simultaneously *at each Pole*, and extending thence *nearly* to the Equator over either hemisphere?"

We have now Mr. Belt's more complete statement before us in the article already quoted, and on the fuller evidence which he has adduced, I admit that his theory deserves our careful study ; and with that conviction I propose to submit it this evening, in as condensed a form as practicable, for your favourable consideration.

In order to present his own speculations in a clearer light, the author first discusses those of Sir Charles Lyell and Mr. Croll.

He refers to Lyell's theory that changes of climate in past epochs were due to a change in the relative distribution of the continents and oceans, and points out that Sir Charles himself no longer relies on this cause alone, but upon a combination of astronomical causes, with certain geographical changes.

In considering Mr. Croll's theory of an increase in the ellipticity of the earth's orbit, we must not omit to remember the vastness of time it occupies. The last period was about 200,000 years ago, and when at its greatest eccentricity, in aphelion, the earth was 98,500,000 miles distant from the sun, or 8,500,000 miles further off than at the present time.

The eccentricity of the earth's orbit, combined with the obliquity of its ecliptic, would give us the sun 7½ days longer in the northern hemisphere than in the southern ; the latter would therefore have 7½ days less summer, and a corresponding extension of its winter period. In consequence of this (according to Mr. Croll), that hemisphere, in winter solstice, when the earth was in aphelion, would lose more heat by radiation into space during the long Polar night than it would gain in the short hot summer from the sun when in perihelion, and it would therefore be growing colder.

But, Mr. Belt replies, radiation goes on by day as well as by night, the warmth of the day depending on the excess of heat received over and above that which is radiated, not that there is no radiation. Taking this into account, we shall find that no more heat is lost in one hemisphere than in the other. Nor does ellipticity affect the absolute amount of heat received from the sun. Therefore, if the absolute amount of heat received, and the absolute loss by radiation, be equal in the two hemispheres, then their mean temperatures, due to these causes alone, must be the same, whatever the amount of the ellipticity of the earth's orbit may be.

Mr. Croll affirms that the lengthened winter in aphelion would enable more ice and snow to accumulate than the short but hot summer in perihelion could melt.

But, Mr. Belt replies, winter does not begin on the day on which the sun passes the autumnal equinox, though what is called the "winter solstice" does. The nights are longer than the days, but snow does not fall, nor water freeze, nor winter actually set in, until many weeks after the 22nd September. Moreover, some excess of heat is stored up in the shorter but hotter summer in the earth, the sea, and the atmosphere, which is not entirely given up till long after the winter solstice has begun. Nor would all the heat so gained be expended in melting the ice accumulated in winter; for a pound of water, in passing from a liquid to a solid state, evolves just as much heat as is required to melt it again. So that the heat given off in winter by water in freezing is equivalent to that absorbed in spring when it melts again. Thus the *mean temperature* remains unaffected.

Clouds are not inimical to climate, for they arrest radiation by night, as well as intercept the sun's rays by day.

Mr. Belt points out a cause (not touched upon by Mr. Croll) why the summer's heat cannot overcome the cold of winter in high latitudes, where snow covers the ground. It is because so much of the sun's heat is reflected back again from the white surface. But for this circumstance, snow would nowhere be perennial, but everywhere the heat of summer would dissolve the snows of winter.

Only at the Poles is there really six months' winter and six months' summer; beyond this, the ice-accumulating period gradually decreases and reaches zero long before we arrive at the Tropics.

Mr. Croll imagines that when the obliquity of the ecliptic was at its *maximum* (24° 50′ 34″), the temperature at the Poles would increase some 15°, and that when the obliquity was at its *minimum* there would be a decrease of temperature. But the reverse of this seems really to be the fact; for if the obliquity be increased the Arctic Circle will be enlarged, and a greater area of the earth's surface brought within the influence of the long Arctic night. A diminished obliquity, on the contrary, would lessen the difference in the Temperate Zone between day and night, and so tend to moderate the extremes of heat and cold in summer and winter.

Thus, by way of illustration, if the obliquity of the earth were diminished to zero, and the axis of rotation perpendicular to the plane of its orbit, the seasons would disappear, and perpetual spring would reign in the Arctic regions. All over the globe there would be 12 hours day and 12 hours night, and no amount of ellipticity of the earth's orbit could have any effect in lengthening the nights or days. (*See woodcut Fig.* 12, *p.* 30.)

An essential part of Mr. Croll's theory is, that during the greatest eccentricity of the earth's orbit, periods of great warmth would alternate with periods of extreme cold. That whilst one hemisphere was undergoing the extreme rigour of a glacial period, the other would rejoice in perpetual summer.

These extremes of climate would oscillate slowly from pole to pole at intervals of 10,500 years; the ice that had been piled up at one pole would melt and be piled up at the other.

According to Mr. Croll's calculations, during the last great period of ellipticity (which occupied 160,000 years), each hemisphere must have alternately passed through *several glacial periods and several warm periods.* If this were so, we ought to find confirmation of these alternations in the successive Faunas and Floras of the Tertiary rocks. Instead of this, however, we find a gradual and continual decrease of temperature in Europe from the earliest Tertiary times. As we ascend in the series, the shells of successive groups of strata consist less and less of southern forms, whilst the northern species are always augmenting, until in the uppermost beds the fauna is very Arctic in character, even in the 52nd and 54th degrees of N. latitude.

The floras, from the Eocene upwards, attest the same gradation, from the palms and tropical fruits of the London Clay to the subtropical *Proteaceæ*, fig-trees, cinnamon, etc., of the Bournemouth beds and of Switzerland; followed by poplar, hornbeam, oak, elm, and other trees now characteristic of temperate latitudes.

The Miocene of Œningen contains many exotic genera, but the facies of the flora indicates a climate which was gradually becoming unsuitable for sub-tropical plants.

In the Lower Pliocene of Italy, most of the sub-tropical genera have disappeared; and in the Newer Pliocene deposits the trees and shrubs are such as characterise European forests, and suggest that the climate was such as is at present enjoyed in Europe. Whilst the Newer Pliocene beds in England, and the Cromer Forest Bed, represent a somewhat lower temperature than the south of Europe, and agreeing with the existing climate of Britain —the lignite beds of Bure and Westleton contain *Salix polaris*, now only known within the Arctic Circle, and *Hypnum turgescens*, an Arctic moss. These last-mentioned beds are succeeded by the Till and Boulder Clay of the Glacial period.

The evidence afforded by the remains of the higher land or marine animals, from the Eocene upwards, yields a precisely similar succession of types, from tropical forms in the Eocene to sub-tropical in the Miocene, more temperate forms in the Pliocene to Arctic Mammalia which usher in the Glacial Epoch.

All the evidence points to a gradual cooling of the climate, and none can be adduced in favour of a succession of warm and cold periods.

The local interglaciation of ice-transported materials in Miocene deposits in Piedmont, and of seams of lignite resting on Boulder-clay at Dürnten, in the Canton Zurich, capped by beds of gravel with erratic blocks, only proves—says Mr. Belt—that in the former case, *as now*, local glaciers existed; and in the latter that peat-mosses accumulated in low swampy places. None of the plant-remains indicate a warmer climate. Cones of Scotch and spruce fir, leaves of oak, ash, and yew, all evidence trees which range far north of Switzerland.

The advance and retreat of the ice of local glacier-systems is a matter of fact within the compass of historic records, as those of the Swiss Alps abundantly testify.

No evidence in favour of a mild interglacial period can be adduced from the shells found in the so-called interglacial beds in Wales, Macclesfield, or South Lancashire; on the contrary, Mr. Geikie admits that "upon the whole, the fossils indicate colder conditions than now obtain in the Irish Sea." Nor do the deposits along our eastern coasts, or those of Ireland or Scandinavia, afford evidence of milder conditions.

The Sicilian Tertiaries have been more favourably preserved than elsewhere, and they attest the fact that the northern forms of Mollusca appear *only in the latest deposits*, and are in no instance accompanied, followed, or immediately preceded by Tropical forms. To obtain these, we must go back to the Miocene and Eocene periods.

Having endeavoured to show that neither by a change in the relative position of land and sea, nor yet by the eccentricity of the earth's orbit, can one in a satisfactory manner account for the Glacial Epoch, Mr. Belt proceeds to propound his theory of a change in the Obliquity of the Ecliptic.

So long ago as 1688, Dr. Robert Hooke endeavoured to explain the evidences of Tropical climates having formerly prevailed in Europe, and indulged in speculations as to a change in the axis of the earth's rotation, or a shifting of the earth's centre of gravity, or a change in the obliquity of the ecliptic.

The last theory was a favourite one among the early English geologists, but received little favour from astronomers. Newton opposed it, and declared that Astronomy could not countenance the theory that there had been any change in the direction of the earth's axis.

Laplace investigated the problem of the effect of the attraction of the sun, moon, and planets on the earth's equatorial protruberance, and came to the conclusion that this could only cause a variation in the obliquity of the ecliptic of 1° 21′.*

More recently, Leverrier examined the same question, and arrived at the result that it might vary 4° 52′, but not more.

The difference between the conclusions of Laplace and Leverrier is a wide one, but assuming these great geometricians could not have erred, there may yet have been other elements of disturbance to be taken into account besides those which they knew and investigated.

Thus, for instance, they assumed the thickening of matter around the Equator to be a constant quantity; whereas there is abundant evidences of great upheaval and depression in remote ages which may have altered the question most materially.

The gradual piling up of ice at the Poles in the Glacial period must have in some measure diminished the difference between the Polar and Equatorial diameters. Even now, many physicists believe that a gradual elevation of land at the Poles, and a depression of land at the Tropics is taking place.

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* Herschel's Astronomy, art. 640.

The Equatorial bulge is not a regular one, but is in the form of an ellipse, of which the greater diameter is two miles longer than the lesser. This has not been taken into account at present, therefore the problem cannot be said to be definitely decided.

The great preponderance of land in one hemisphere, not arranged around the earth, but in a mass whose centre is situated near the English Channel, must also be a disturbing element of no mean importance.

Mr. Belt points out that our knowledge of other planets teaches us that there is *no limit* to the obliquity of their axes.

In JUPITER the axis is nearly perpendicular to its orbit, so that there is no change in the length of the day there on any part of its surface,

In SATURN the obliquity is 29°
In MARS „ „ 30¼° *

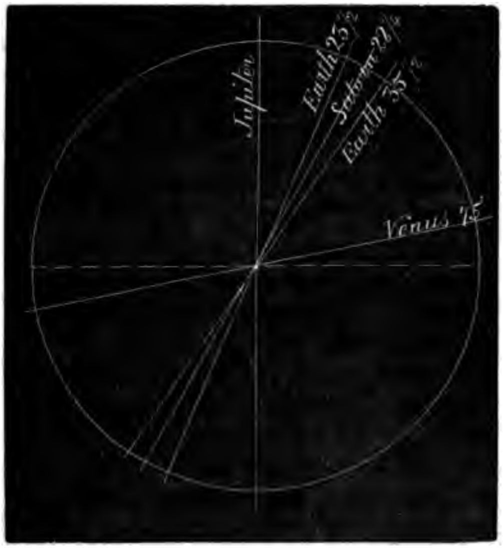

FIG. 5.—Diagram to illustrate the variation in the obliquity of the axes of rotation of certain planets to the plane of their orbits.

And in VENUS it reaches the extreme of 75°, so that its tropics overlap its arctic circle, and there are no temperate zones.

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* Mr. Dunkin, in Lardner's "Handbook of Astronomy" (1867), gives it as 28° 27′. "The exact direction of the axis is, however, still subject to some uncertainty." (p. 210).

The inclination of the polar axis to the plane of our earth's orbit—that is, to the Ecliptic—is 23½°, but it is known that this is diminishing at the rate of 48″ in a century.

As no original cause for the inclination of the axes of the planets has been assigned, it may be allowable to suppose that changes in the obliquity of our earth's ecliptic may occur through the same series of causes as have originated it in our own and other planetary bodies.

The Rev. Professor Haughton, F.R.S., of Dublin, a most able mathematician and geologist, writing in McClintock's "Voyage of the *Fox*," in 1859 (p. 395), observes: "The only speculation I am acquainted with, which is capable of solving this *opprobrium geologicorum* is the hypothesis of a change in the axis of rotation of the earth, the admission of which as a geological possibility is mathematically demonstrable, and which has recently had some singular evidence in its favour advanced by geologists."

It is an established fact that the obliquity of our earth is less than it was some centuries ago. But this, it is argued, is due to those small variations that Laplace and Leverrier showed to be possible; that the outline of the polar circle is a waved one, and that during the time these observations were made the direction of the pole has been down towards one of these waves; but that it will again rise as much above as it has dipped below.

The movement of the pole is, in all probability, that of an ellipse, or of a spiral, as none of the heavenly bodies describe a circle, all the orbits being ellipses of varying degree.

This question needs to be re-investigated by the astronomer; meantime geologists are at liberty to speculate on the possibility of great changes in the obliquity of the Ecliptic having caused former great variations of temperature.

According to Lieut.-Col. Drayson, the obliquity has been as much as 35°. The effect of this was, he supposed, the production of the Glacial Period. The Arctic Circle would then reach nearly to Lat. 54½°; there would be an accumulation of snow during the winter, which in summer would all be melted *nearly* to the Poles, causing enormous floods. But if this would really be the effect of the greater obliquity of the ecliptic, we might at once dismiss it as a possible cause of the accumulation of ice during the Glacial period.

Such results might very well accord with Mr. Alford Tylor's theory of a great Pluvial period.

When we consider the enormous masses of ice (thousands of feet in thickness) which we know, from their "spoor," must have moved down southwards over the northern parts of Europe, Asia, and America, we are sure that they could not have been produced from the snowfall of a single winter.

Let us consider for a moment the question of the effects of the present inclination of the earth's axis.

Fig. 6.

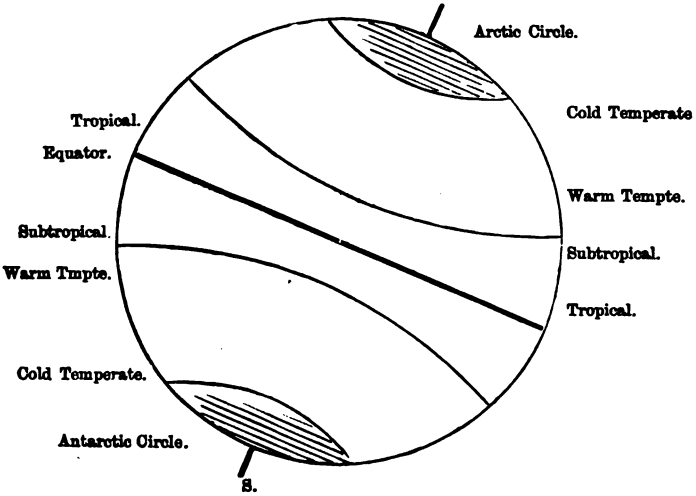

Fig. 6.—The Earth at the present period, having an obliquity of 23½° to the plane of its orbit, producing all the variations, in climate, from temperate to arctic conditions, and in length of day and night 12 hours daylight and 12 hours night at the Equator, to 6 months day and 6 months night at the Poles.

To it is due the varying length of days throughout the year in the Temperate and Arctic zones, and the consequent production of the Seasons. If the axis were perpendicular (see Fig. 12) as in Jupiter there would be one uniform day and night, and one uniform climate, throughout the world. The piling up of ice and snow at the sea-level would be impossible, except, perhaps, in the immediate neighbourhood of the Poles, where, from the small altitude of the sun, its rays would have but little heating power.

Our seasons are, then, due to the present obliquity of the Ecliptic; as also the glaciation of circumpolar lands; indeed, but for that obliquity, snow and ice could not accumulate save upon mountain chains.

The obliquity of the Ecliptic does not affect the mean amount of heat received from the sun at any given point, which remains the same, but it causes the heat and the cold to predominate at different seasons of the year.

Thus, near the Poles, there are six months night and six months day ; but the absolute amount of heat that arrives from the sun is the same as if there were twelve hours' light and twelve hours' darkness every day.

Mr. Belt affirms that neither the cooling of the air by the melting of the snow in summer, nor the formation of clouds, tend to prevent the accumulation of snows from year to year, but that their conservation is due really to the reflection of the sun's rays by the white, snow-covered surface of the earth. Therefore a country which endures a long hot summer and a long cold winter is more likely to favour the accumulation of perennial snow than another under similar conditions of sunlight and warmth, but where the sun rose and set every twelve hours, so that the heat by day and the cold by night were never so excessive.

FIG. 7.

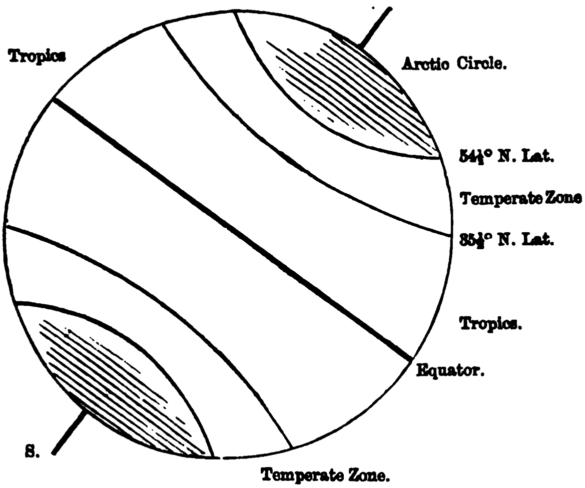

FIG. 7.—Ideal figure of the Earth in the Glacial period. The axis (like that of Mars at the present day) is assumed to have then been more inclined towards the plane of its orbit than now, and, like Mars, both poles were greatly glaciated.

If the obliquity of our earth were increased, a greater and yet greater area would be brought under Arctic conditions. When the obliquity reached 35½°, the Arctic Circle would extend to Lat. 54½°, and the Tropics to 35½°, reducing the Temperate Zones from their present width of 43° each, to 19°, one-half the decrease being added to the Tropics, and the other half to the Arctic Zone. (See Fig. 7.) The half near the Equator would have its temperature greatly raised, and become an additional area of evaporation; whilst that nearest the Poles would be an additional area of condensation.

As the ice extended and consolidated, it would gradually shut off the warm currents of the ocean, now extending nearly to the Pole, and the heat so diverted would tend to assist and increase evaporation, and thus precipitation would also be proportionably increased.

It is a fundamental part of Mr. Croll's theory (already discussed) that the glaciation of the two hemispheres should take place separately and alternately.

It is an equally fundamental principle of Mr. Belt's theory that they should be glaciated simultaneously.

In support of his views, Mr. Belt reminds us—

(*a*) That glacial conditions due to the obliquity of the Ecliptic exist at the present time around *both Poles*.

FIG. 8.

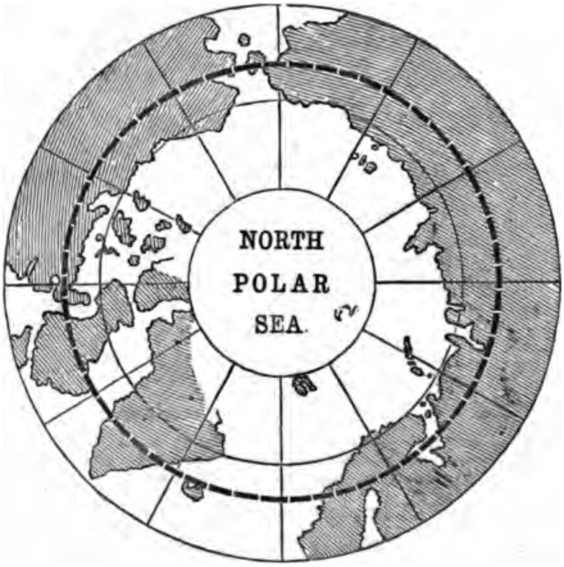

FIG. 8.—Diagram of North Polar Sea, to contrast with South Pole. The South Pole having a land-surface surrounded on all sides by water; whereas the North Pole appears to be a marine area almost entirely surrounded by land.

That more ice is heaped on the Antarctic regions than upon the Arctic is explicable by the fact that a larger area for evaporation is afforded in the southern hemisphere by its more extended ocean basins; whereas, in the north, not only are the Arctic regions almost encircled by lands, and so offer a far less area for evaporation, but much of the snow which would doubtless reach the Polar regions is intercepted by mountain chains and added to local glacier systems, such as the Alps, the Himalayas, and other high northern ranges. (Compare Diagrams, Figs. 8 and 9.)

FIG. 9.

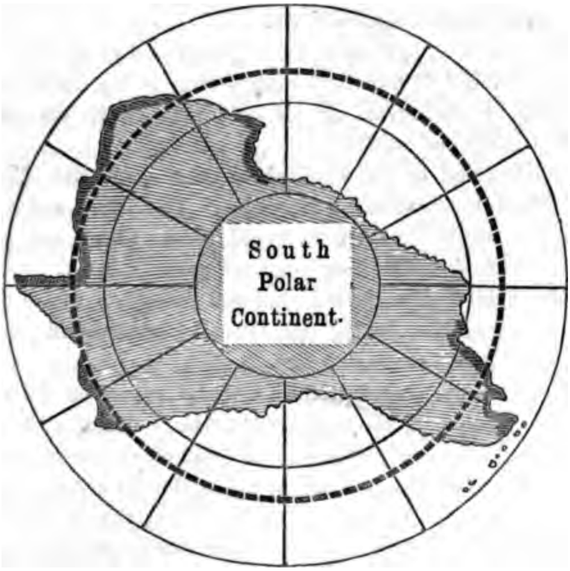

FIG. 9.—Diagram of the South Polar Continent, to illustrate the vast land area forming the gathering ground for the great Antarctic Icebergs, referred to by Mr. James Croll. (See p. 5.)

The darker parts along the margins of the South Polar Land indicate those portions which have been, more or less, accurately surveyed, such as South Victoria Land (with Mount Erebus), Enderby Land, Trinity Land, &c.

That the difference is due to lessened precipitation, and not to differences of temperature, will be seen by following the isotherm of 30° around each hemisphere.

In the southern hemisphere it deviates but little from the line of 60° S. Lat. In the north it is much more irregular, but the mean is again about 60° N. Lat., proving that if the precipitation were the same, there would be as much snow and ice north of Lat. 60° N. as there is south of Lat. 60° S.

(*b*) Accumulations of snow have only been observed on one planet, viz., Mars, which, with an obliquity of 31½°, is *glaciated at both Poles* at the same time.

Judging, then, from analogy, we might expect the Glacial period to have been *contemporaneous* in both hemispheres.

(*c*) Many plants and animals are found in both the northern and southern temperate zones, having close affinities, and even pointing to a common origin, yet separated by the whole width of the Tropics, which they cannot now pass.

Mr. Darwin has explained their presence by supposing that during the Glacial Period they were driven to the high lands of the Tropics by the advancing ice, and that on its retreat they followed it north and south.

A glacial period in one hemisphere only would not, Mr. Belt thinks, afford this means of migration. The plants and animals driven south by the northern ice would always have a hot zone to the south of them which they could not pass.

(*d*) Mr. Tylor has suggested that the piling up of ice in the northern hemispheres during the Glacial Period would lower the level of the general ocean 600 feet.

Mr. Croll, on the contrary, in his recent papers on this subject (Geol. Mag., July and August, 1874), shows that if each hemisphere were glaciated alternately, the level of the ocean would be raised and *not* lowered in the one in which the ice accumulated (as already explained) by the melting of the ice at the opposite pole, and the shifting of the centre of the earth's gravity towards that covered by an ice-cap. (See p. 6, Fig. 4.)

Mr. Belt concludes that one Polar ice-cap could not materially lower the general ocean if the opposite pole was freed from ice; but, on the contrary, if the Glacial Period in the two hemispheres was contemporaneous, then the water abstracted from the sea and frozen into ice at the Poles, together with that impounded in the great lakes of North America, North Europe, and North Asia, by the blockade of the northern drainage of the continents with ice, must have lowered the general level of the ocean to a great extent.

From data gathered in Central America, and in Siberia, Mr. Belt estimates the lowering of the sea-level by the accumulation of ice at the Poles could not have been less than 2,000 feet, and may have been much more.

Applying this result to the solution of the problem of insular floras and faunas, the author points out that their derivation has usually been explained by supposing such islands to have been at one time joined to the continents nearest to them, and to each other in Post-Tertiary times. In every case, therefore, the last movement has been one of depression, the bridge by which they passed over has been submerged and destroyed.

The lands uniting Greenland with Europe, England with Ireland and with the Continent, Malta with Africa, the Malay Archipelago with Asia, on the one hand, and with Australia on the other, the West Indian Islands with Venezuela and Yucatan, and that uniting Tasmania with Australia, are all supposed to have been submerged by a sinking of land, unaccompanied, in most instances, by a corresponding elevation.

It is a significant fact, first noticed by Wallace, that whilst all islands having *shallow channels*, however broad, separating them from each other, and from not distant continents, give evidence of a former connection in Post-Tertiary times; on the other hand, islands surrounded by *deep water* are marked by peculiar faunas.

Thus Madagascar, though near the coast of Africa, is separated by a deep sea, and its fauna and flora are singularly distinct.

The Galapagos Islands have also a peculiar fauna, indicating the antiquity of their insulation.

A uniform lowering of the sea-level would afford a satisfactory solution to these difficulties, which cannot so readily be explained by local subsidences and elevations.

Again, the ancient Submerged Forests so frequently to be met with around our coasts almost everywhere pass under the bed of the ocean. Mr. Lucy, F.G.S., in a recent communication to the Cotteswold Club, "On the Submerged Forest at Sharpness," records the occurrence of 25 of these old littoral forest-tracts, now destroyed by the invasion of the sea around our coasts. Their present submerged condition can easily be explained if we assume that the sea has risen above them, not that the land has subsided.

The upward growth of Coral-islands from great depths affords another admirable case which the theory of Mr. Belt serves to explain. Darwin first proved that they were due to the gradual deepening of the ocean bed from which the coral islands rise. Dana estimated the deepening to be at least 3,000 feet, and that the subsidence extended around one-fourth of the earth's circumference in the Pacific, marked by atolls for 6,000 miles in length and 2,000 in breadth. The Bahamas also cover a submerged area of land 600 miles in extent from N.W. to S.E., whilst the long line of the Florida Keys trending away from the land of Southern Florida, evidence the same downward movement.

A rise of the sea, owing to the increase of its volume—liberated after the Glacial Period from the ice of the Polar regions—would produce the same effect as the lowering of the land, which might not occur *generally* with the same precision of level as that of the waters of the ocean.

Again, the continent of South America—and indeed the mountain chains generally, all over the world—testify to the fact that they have been glaciated to lower levels upon their slopes than that to which ice and snow now descend, or where they occur perennially. A general lowering of the sea-level would produce precisely the same effect on climate as the raising of the continental surfaces; the atmosphere, following down, would bring the freezing point so much lower than it otherwise would be.

An increase in the present obliquity of the Ecliptic would not only permit a greatly-increased accumulation of ice on circum-Polar lands, but it would be the cause of lowering the mean temperature of the Tropics; so that the snow-line would even descend still further from increased precipitation, due to the greater evaporation.

An examination of the deltas of great rivers, such as the Ganges, the Mississippi, the Nile, and the Po,* has shown that there are numerous land-surfaces and fresh-water deposits *hundreds of feet below* the level of the sea. Indeed, the channels of most of our rivers are really much deeper cut than their present bed.

Mr. Belt thinks that evidence of the close of the Glacial Epoch, and of the gradual retreat and melting of the ice in lower latitudes, may be found in those universal traditions of mankind as to floodsand inundations, the heritage alike of civilized and barbarous races. Whether this be so or not, it is at least satisfactory to be able, as geologists, to indicate a probable cause which may adequately explain these wide-spread legends of the Deluge.

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* See Alfred Tylor's paper on the Delta of the Po: Geol. Mag., 1872, Vol. IX., p. 392 and 485.

If man had already peopled the earth in the still older times when—

> A solid wall of ice hemmed in the earth
> Both north and south; from which, at times,
> Huge fragments, sailing forth, by ocean borne,
> Grounded on old Atlantis' fabled strand,
> Cooling the breeze for many a league around

—then the difficulties of the anthropologist are also greatly reduced; for many an island, beside the fabled Atlantis, or St. Brandred's Isle, then lifted its head above the wave, and many a—*to us*—pre-historic Columbus accomplished with ease what our modern discoverer achieved with so much difficulty less than 400 years ago.*

If, as Mr. Belt concludes, the melting as well as the accumulation of the ice of the Glacial Period must have occupied thousands of years in accomplishment, this is quite in accordance with the gradual growth of coral-reefs, and the silting up of deltas filled with fresh water deposits. But probably some sudden rises did from time to time occur, causing local floods and the inundation of vast low-lying tracts of country.

Since the close of the great Ice Age, there is clear and indisputable *evidence of the rise of land* both towards the North and South Pole, which is probably even now in progress.

In the south, the extremity of South America, and a part of New Zealand, has been elevated.

In the north, the coasts of Scandinavia, commencing on the eastern side near Stockholm, and on the western coast near Gothenburg, and increasing northwards as far as the North Cape. The raised beaches, with Arctic shells, everywhere rest upon Boulder-clay with transported blocks.

The coasts of the Arctic Sea are also slowly rising (according to Adminal von Wrangel); marine beds containing shells of existing species, together with remains of the Mammoth, occur several feet above the present sea-level.

On the American side, the elevation commences near New York, where, at Brooklyn, raised sea-beaches, with marine shells, occur 100 feet above the present level of the sea. This elevation increases in a northerly direction. At Quebec and Montreal it reaches to 400 and 500 feet, whilst still further north, within the Arctic Circle, on the shores of Barrow Straits, sea-shells of *existing species* have been carried up to a height of 1000 feet above the ocean. The movement clearly increases towards the Pole.

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* A.D. 1492, Discovery of America by Christopher Columbus.

A part of the coast of Greenland is said to be in a state of subsidence, but Greenland *is now* undergoing *intense glaciation*, and is buried in snow and ice piled mountains high. All the geological evidence is in favour of these lands having been above the sea in pre-Glacial times. The lands around the Poles must then have sank down after they were covered with ice, and they have been slowly rising since it melted away.

Mr. Belt believes the *cause of the depression* was the piling up of so vast a weight of ice around the Poles, and that the *cause of the elevation* was the removal of that vast weight by the gradual melting of the ice.

FIG. 10.

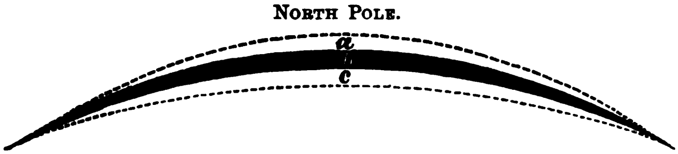

FIG. 10.—Diagram to illustrate Mr. Belt's theory of the depression of land at the Poles during the Glacial Epoch, by the heaping up of ice *(a)*, causing the crust *(b)* to be depressed to *(c)*, which again rises to *(b)* upon the removal of the Ice-cap *(a)*.

That the movement of elevation still continues in some places only shows that the earth is a (more or less) rigid body, and but slowly gives way to great strains.

In considering the theories which have been put forward in order to account for the cold of the Glacial Epoch, one important point to be borne in mind is, the *relative time* assumed to be occupied by the respective operations of eccentricity of the earth's orbit on the one hand, and by the greater obliquity of the Ecliptic on the other.

Thus, Mr. Croll's theory of the eccentricity of the earth's orbit requires a period of 200,000 years to elapse. On the other hand, Mr. Belt's theory of the greater obliquity of the Ecliptic would not require much more than 20,000 years, or one-tenth of the time demanded by Mr. Croll.

We have not the least desire needlessly to question the time assumed to be required for the completion of any particular geological change on our earth; but if each deposit, as we recede in time, represents, as there is reason to believe, a longer and yet longer period of our earth's past history than that which preceded it, it becomes very like the old story of doubling the price of the nails in the horse's shoes—the sum becomes millions long before we reach the base of the Palæozoic rocks, and the earliest traces of life on the earth.

Diagram illustrating the comparative thicknesses of the several Deposits forming the stratified crust of the Earth.

			Feet.	Thickness.
Post Tertiary		Recent ...	50	
		Glacial ...	200	
				250 feet
Tertiary ...		Pliocene ...	100	
		Miocene ...	125	
		Eocene ...	2,600	
				2,825 „
Secondary ...		Cretaceous ...	1,420	
		Wealden ...	750	
		Jurassic ...	2,750	
		Triassic ...	1,800	
				6,720 „
Primary ...	Newer ...	Permian ...	600	
		Carboniferous ...	15,000	
		Old Red Sandstone	6,000	
				21,600 „
	Older ...	Silurian ...	24,000	
		Cambrian ...	20,000	
		Laurentian ...	30,000	
				74,000 „
			Total ...	105.395 feet = 20 miles.

Relative Thickness (after Hæckel:—*corrected*).

Quaternary	·2.
Tertiary	2·7.
Secondary	6·4.
Newer Palæozoic	20·3.
Older Palæozoic..	70·4.

But to resume:—

If our Glacial period merely necessitated, as Mr. Croll supposes, the heaping up of snow and ice around the North Pole, the only result would be a slight shifting of the centre of gravity of the earth northwards; but if it was contemporaneous in the two hemispheres (as Mr. Belt assumes), the figure of the earth would be changed, its Polar diameter would be lengthened, its mean Equatorial diameter shortened, and a series of strains would be

FIG. 11.

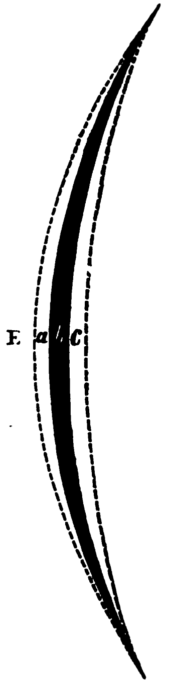

FIG. 11.—Diagram to illustrate the increase of the Equatorial diameter during the Glacial Epoch, and the diminution of the Equatorial bulge since; caused by the removal of the Polar Ice-caps. E. the equator. (See also fig. 10, p. 24.)

set up, tending to restore its figure to a state of equilibrium. (Figs. 10 and 11.)

And if, during the Glacial Epoch, that state had been arrived at by the sinking down of the circumpolar land, and the rising of land in the Tropics, then, when the ice melted away, the Polar diameter would be shortened, the mean Equatorial diameter lengthened, and forces would be set in operation tending to lower the land at the Tropics, and raise that around the Poles.

That the deepening of tropical seas, as evidenced by the growth of coral islands, is due to an actual sinking of the bed of the ocean is perfectly in accord with this theory. But whether by the deepening of the sea by addition to its volume, or by depression of its bed, the cause (according to Mr. Belt) has been the gradual melting of the ice piled up during the Glacial Epoch, which, by its liberation, has disturbed the equilibrium of the figure of the earth.

The movements of the earth's surface have hitherto been ascribed to the contraction of its crust by secular cooling. But Laplace, reasoning on the astonomical observations of Hipparchus, could find no appreciable difference from the contraction of the earth during the last 2,000 years. The length of the day has not been shortened by even the space of 1-30th of a second, so that the contraction, if any, must be in-appreciable.

Mr. Belt thinks that even the radiation of heat into space is probably not greater than that which our earth receives from the sun, and that he is justified in concluding that volcanos and earthquakes, and the increase of heat in mines, are all referable to the strains set in action by the melting of the ice-caps of the Glacial Period.

The insufficiency of the central heat theory is shown by the state of the ground in Northern Siberia. At Yakutsk the soil—

save a few feet which is thawed every summer—is *permanently frozen* to a depth of about 400 feet.

This soil extends to the shores of the Frozen Sea, the cliffs bordering the rivers being in many places composed of alternate layers of soil and ice. It is in these cliffs that the bodies of the Arctic Rhinoceros and Mammoth have been found, with their flesh still preserved. The soil cannot have been thawed for a single season since they were entombed, or their flesh would have putrefied. The ice, therefore, is as old as the close of the Glacial Period, at which time these great animals flourished.

It could not have remained frozen, however, at a depth of 400 feet from the surface if the earth were a cooling globe. If, however, the heat of the earth be due to movements within it, we can understand that in Siberia it may not have been developed to the same extent as elsewhere ; for, according to Murchison, Siberia is a country of great geological stability ; von Cotta even thinks it has never been submerged since the close of the Permian period.

From a personal examination, Mr. Belt finds that the steppes are composed of freshwater deposits, excepting those on the extreme northern border of the country.

If it be true that volcanos are due to movements of the crust of the earth—*not to secular cooling*—but to those forces tending to restore the equilibrium of the earth's figure—disturbed alternately by the accretion of ice at the Poles during the Glacial Period, and to its subsequent liquefaction, it will add yet another to the many marvellous effects due to the action of the sun upon our planet.

Whether the earlier and greater geological folds and upheavals may not be due to other causes, is not ventured to be denied.

But in accounting for the cold of the Glacial Period we have only answered half the problem we are called upon to solve. There is the heat of early Tertiary times to be likewise explained.

Over barren wastes, with here and there a stunted bush of *Salix polaris*, or a scanty covering of Arctic mosses and lichens ; where the musk ox and Greenland lemming found their northern limit in summer, there stretched, at the commencement of the Tertiary period, rich and luxuriant tropical forests. Palm trees, of types now restricted to the Moluccas, the Philippines and Bengal, with custard apples, melons, and many other tropical plants, flourished in the neighbourhood of Paris and London.

Huge animals resembling tapirs, but larger, roamed in the forests; monkeys chattered amongst the trees; tortoises and other cheloniæ abounded along its shores, whilst sea-snakes, crocodiles, and enormous sharks tenanted the waters.

The climate of the Eocene period was even *much warmer* in proportion than that of the great ice age was colder than the present.

Mr. Carruthers lately remarked to me that even at the present time snow lies in the hollows of the Grampians all the year round.

Indeed, if we had a mountain near London, 6,000 feet high, we should have its top covered by perennial snow.

When the tropical fauna and flora occupied central Europe as far as 52° N. lat., still nearer the Pole, vegetation flourished similar to that which characterizes the milder portions of the Temperate Zone, and the representatives of our present fauna and flora in Northern Europe lived and throve within 11° of the Pole.

Thus at Spitzbergen, far within the Arctic Circle, in latitude 78° 56′ flourished species of hazel, plane, poplar, lime, and beech trees. Professor Heer is of opinion that firs and poplars must have reached to the pole itself, if there was land for them to grow on.

The Arctic plant-beds are described as of "Miocene Age," because out of 137 species of plants found in Greenland, 46, or one-third, are identical with those of Miocene age in Central Europe. This fact seems, however, to favour the opposite conclusion. It is improbable that so many species should have had such a wide range.

As in the Eocene period, central Europe was occupied by a sub-tropical fauna and flora. Mr. Belt asks—Is it not most probable when the greatest heat prevailed in Europe, that was also the time of the greatest heat within the Arctic Circle, and that on the advent of the cooler Miocene climate some of the species, living much further north, migrated southwards into central Europe, and took the place of the Eocene flora, for which the climate had then become too cool?

That many deposits, hitherto referred to different geological ages, have been actually accumulated contemporaneously in contiguous areas, is now becoming a recognised fact, yet few are aware that the doctrine was enunciated nearly fifty years ago by Mr. G. Poulett Scrope,* and subsequently was more carefully elaborated by the late Professor Edward Forbes.†

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* Scrope, Volcanos, 1825, p. 239.

† See Wilson and Geikie's Memoir of Forbes, p. 395.

Heer records more than sixty different species of plants from N. Greenland in latitude 70° N.* Amongst them *Sequoia Langsdorfi*, cones of the Magnolia, vines, and broad-leaved ferns were abundant. The trunks of some of the trees were thicker than a man's body.† In Spitzbergen they were equally abundant in Lat. 78° 56′ N., *or within* 11 *degrees of the Pole.*

No redistribution of land could make the climate of Spitzbergen more tolerable than it is, lying as it does in the line of the warm current, nor could it obviate the length of the Arctic night, which must prove fatal to all the higher types of vegetation.

The shortest night attainable in Arctic regions under present astronomical allowances is three months, during which the sun would not rise above the horizon.

"It is well worthy of remark" (writes the Rev. Professor Haughton),‡ "that the arguments from the occurrence of coal-plants and ammonites strengthen each other; the coal-plants rendering the question of *light*, and the ammonites that of *heat* insuperable objections to the admission of any received geological hypothesis to account for the finding of such remains *in situ*, in latitudes so high as those of Melville Island, Prince Patrick's Island, and Exmouth Island."

The presence then of trees in Tertiary deposits in Greenland and Spitzbergen may serve as a crucial test for this investigation.

The long Arctic nights are caused by the obliquity of the Ecliptic, and only by the lessening of that obliquity can they be shortened.

Having shown that an increase of cold at both Poles would result from a greater obliquity of the Ecliptic, let us consider the effect of a great decrease in that obliquity.

The present position of the axis of Jupiter proves that there is nothing impossible in the supposition that the axis of the earth may also, at one time, have been perpendicular to the plane of its orbit. The immediate effect of such a change would be the equalisation of day and night all over the globe. Every parallel of latitude would have but one season. At the equator alone would the sun rise vertical overhead at noon. In the temperate zones would reign perpetual summer, and within the Arctic Circle perpetual spring. In central Europe subtropical vegetation might then flourish.

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* See Prof. Heer's "Lecture on the Miocene Flora of the Polar Regions," Geol. Mag., 1868, Vol. v., p. 273.

† See "Nordenskiöld's Expedition to Greenland," Geol. Mag., 1872, Vol. ix. p. 456.

‡ Appendix p. 395, to McClintock's "Voyage of the Fox" (1859).

FIG. 12.

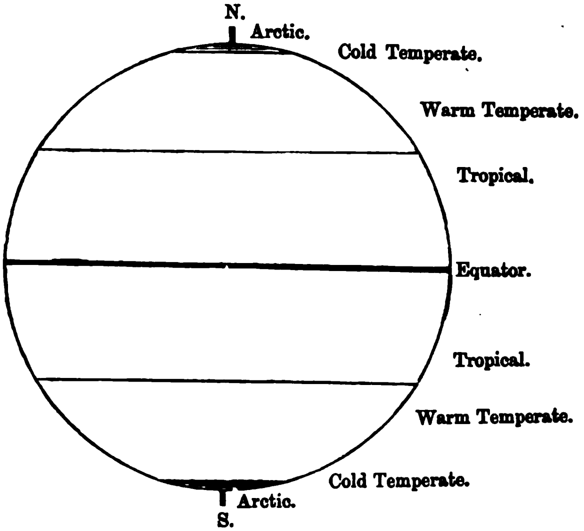

FIG. 12.—Ideal figure of the Earth in the European Eocene Period. The Axis (like that of Jupiter at the present time) is assumed to have then been perpendicular to the plane of its orbit.

In North Greenland the sun would rise every day to a height of 20° above the horizon and give twelve hours' sunshine. Spitzbergen would be colder, as the sun would rise to such a small altitude above the horizon, but even there, says Mr. Belt, the warmth of the Gulf-stream would cause frost to be unknown.

I fear I may have wearied your patience by this lengthened exposition of the new Glacial hypothesis, and, after all, may have failed in my attempt to place clearly before you the main points to which I desire to direct your thoughts. On the question of the internal heat or cold of the interior of our earth, I will not descant; but the theory of the variation of the obliquity of the Ecliptic should not be allowed to remain long unsettled after this date.

May we, as geologists, venture to question the past verdict of astronomers on this point? And may we ask them to re-examine their data? I think we may safely do so. For the internal evidence afforded by the Tertiary Floras of Greenland and Spitzbergen, and the conclusions of some of our ablest Botanists, as

Heer and Carruthers, thereon, are as incontrovertible as the effects of gravitation. Happily for the younger school of geologists, astronomers no longer *insist* on our conceding to them the dogma of infallibility. Popes in Science, who would bend facts to fit theories, are quickly dethroned now a-days, and only those theorists command our respect who build upon a coherent foundation of well-arranged facts. If in the Tertiary epoch the earth's axis has passed through a gradual movement from a position in which, like Jupiter, its axis was perpendicular to the plane of its orbit, to one in which, like Mars, its axis was inclined at an angle of 30° or even 35°, and if it be now as slowly returning to its former phase, it seems but probable, that in past geological ages the same slow variations have been taking place, producing, at long intervals, the same climatal changes we have just discussed.

Prof. Ramsay, Mr. Geikie, and others, believe they have detected physical evidences of several past glacial epochs—it is for the palæontologist to apply climatal tests to the older faunas, in order to confirm or refute these conclusions.

During the past year Mr. J. W. Judd, Profs. Geikie and Hull, have contributed to our knowledge of the existence in Ireland and the Western Highlands of successive series of volcanic rocks capable of identification with periods of eruptive activity in the Silurian, the Old Red and the Tertiary periods. Several of the volcanic vents have been discovered with their "necks" still surrounded by bombs and scoriæ, clearly indicating the sites of eruptions similar in character and in their attendant phenomena to those of to-day. There is no *ground*, then, for the assertion of Mr. Robert Mallet that the later volcanos alone have thrown out ashes and scoriæ, and the earlier only lavas.

That Lundy Island may probably be, as pointed out by Mr. Judd, relegated to the same volcanic series as that of the Western Highlands; and, as Mr. Allport has more recently suggested, that the "Wolf Rock" between Land's-end and the Scilly Islands may probably mark a more southern extension of this great line of Tertiary volcanic action—the thermal springs at Bath, so long isolated, now form an harmonious link in the chain of evidence (referred to in my last year's address), attesting an axis of volcanic disturbance running north and south equal in longitude to that of the two Americas, although now in great part sunk beneath the Atlantic.

This Association is essentially a practical one, as a retrospect of its published proceedings will clearly attest. Even in the past twelve months sufficient good solid work has been accomplished to lift it above the level of a mere dilettanti society. And if, in the earlier days of its existence, some among its promoters may have formed somewhat utopian notions as to its future career, the more practical working members have fully achieved for it a high character for usefulness and durability.

Since its foundation in 1858, a period of sixteen years has elapsed and although from 1863 to 1870 the Association appears to have somewhat languished, yet, on the whole, the amount of work done and of country traversed geologically has been very considerable. More than 100 excursions have been made, and nearly 200 papers read, of which a large proportion have already been published in our "Proceedings."

But whilst congratulating you on the progress of the Association hitherto, let us not, like the Lotophagi, rest lost in idle contemplation—

> "Propt on beds of amaranth and moly,"

but rather seek new grounds to explore, new materials to classify, and new theories to be tested.

As a London society, we are especially interested in all connected with the Thames valley. Can we not complete the history of its past faunas, and map its old physical conditions?

Mr. William Davies, of the British Museum, has this year completed an admirable catalogue of its Pleistocene Mammalia, as illustrated by the grand collection from the Brick-earth at Ilford, formed by Sir Antonio Brady, Knt., F.G.S. (now in the British Museum). May we not add to this?

The valuable work by our late lamented friend and associate, Professor Phillips contains much; surely, we may still add more.

Mr. Frederick Edwards' celebrated collection of Eocene Tertiary fossils, and that of Mr. Nathaniel Wetherell, F.G.S., of Highgate, are now national property, and are easily accessible to the scientific student. Of the 2885 species of Eocene mollusca in Mr. Edwards' collection, 742 species are MS, and need to be described and figured. The Palæontographical Society will find the plates; who will volunteer to find the descriptions? I believe in this Association we have at least three or four members fully qualified, and probably quite willing to combine and carry out this object.

Our excellent Vice-President, Mr. Robert Etheridge, F.R.S., has kindly furnished me the latest column in the subjoined table, from which it appears that there are 13,275 species of described British fossils.

	Dr. H. G. Bronn's Index Palæontologicus, 1849. (Cosmopolitan)	TOTAL.	Prof. Morris's Catalogue of British Fossils, 1854.	TOTAL.	Mr. Robert Etheridge's List of British Fossils, 1874.
VERTEBRATA.					
MAMMALIA	708	......	97	......	198
AVES	148	......	12	......	18
REPTILIA	384	......	184	......	280
PISCES	1,461	......	755	......	883
Total VERTEBRATA		2,701		1,048	— 1,379
INVERTEBRATA.					
Insecta, etc............	1,699	......	74	......	97
Crustacea	894	......	367	......	996
Annelida	292	......	137	......	194
Mollusca	13,885	......	5,057	......	7,416
Polyzoa	810	......	264	......	534
Echinodermata	1,232	......	494	......	681
Zoophyta	825	......	474	......	573
Protozoa	2,028	......	395	......	582
Total INVERTEBRATA		21,665		7,262	— 11,073
PLANTÆ.	....	2,055		729	823 823
GRAND TOTAL	....	26,421		9,039	13,275
	Probablynot less than fossils have been described in Europe and America, etc., since	12,500	If to the above we add for the newly described species during	6,000*	
	1849, making as the Total for all the world	38,921	the past 20 years, we shall have British Fossils...	15,039	

I have estimated the cosmopolitan lists roughly at 39,000 species, so that we may still hope to find many more new forms in Britain.

One of our Members, Mr. Hopkinson, is already prepared to make a considerable addition to the Graptolites of the Arenig Group; Mr. F. G. H. Price and Mr. Gardner are both working up the Fauna of the Gault; the latter gentleman hopes (aided by Mr. Carruthers, F.R.S.), to monograph the Flora of the Bournemouth and Alum Bay Plant-beds. Many British Fossil Crustacea still remain to be described, and I have also a new fossil Scorpion from the Coal-measures of Sandwell Park Colliery, near Birmingham, to place before you shortly.

Our able Honorary Secretary, Mr. Hudleston, will this Session present his second great paper on the Oolites for your acceptance, and our distinguished colleague, Professor Morris, has incidentally mentioned that he has several discourses ready for delivery on a variety of topics, but especially upon the appearance of the great groups of animals in time, and their relation to the functions which they fulfil, as well as to each other.

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* The admirable summary given by the Rev. Thos. Wiltshire, M.A., F.G.S., V.P.G.A., the Hon. Sec., in this year's volume of the Palæontographical Society, shows that during the 28 years of its operations upwards of 4,000 British species have been described and figured in the Society's Monographs.

Mr. G. Smith, another of our Members, has prepared with great skill and ability more than 100 sun-pictures of fossils illustrative of the chief types of ancient life on our planet, well suited for lecture-purposes, and admirably adapted to promote a taste for geological studies among the young.

I have already had the pleasure to exhibit some of these (by means of the oxy-hydrogen lantern) before the Members of this Association during the course of last Session, but many new ones have lately been added to the series. I have much pleasure in commending them for their accuracy and clearness. They deserve to be very widely known, and are sure to be appreciated.

According to established custom, I shall vacate this chair at the next Annual Meeting in February, 1875, but it is not my intention to cease to co-operate with you, or to feel a lively interest in the welfare of the Association, which has done me the honour to call me to its highest office, a position I feel I am but little worthy to occupy.

In his Anniversary Address to the Geological Society of London in February last, His Grace the Duke of Argyll has laboured to point out how much, as geologists, we have yet to learn concerning this great universe "in which we live and move and have our being," and he has reminded us of the words of that excellent and highly-gifted lady, Mrs. Somerville, who exclaimed, after a life given up to the earnest pursuit of science, "Ah! how little it is we know."

While fully concurring in that truth, as applied to geology, I would record here another equally terse and apt remark which fell from the lips of my esteemed friend, Professor Morris, a few days since. It is—"*How much we owe* to that Older School of Geologists, who, fifty years ago, first expounded the great and fundamental facts of geology for us, and yet whose writings we too often pass over unread, and whose very names will soon be forgotten by the Younger School of Geologists."

ORDINARY MEETING, February 6th, 1874.

Henry Woodward, Esq., F.R.S., F.G.S., &c., President, in the Chair.

The following Donations were announced:—

"Catalogue of the Library of the Corporation of London."

"Abstract of Proceedings of the Geological Society," from that Society.

Henry Alpha Burrows, Esq., was elected a Member of the Association.

The following Papers were read:—

1. On the Probability of Finding Coal in the Eastern Counties.

By John Gunn, Esq., M.A., F.G.S.

In my former paper, "On the dip of the Chalk in Norfolk," I pointed out that the Chalk, which had been horizontally deposited, was upraised about 1,700 feet at Hunstanton, where it crops out together with the Lower Greensand.

The object of my present paper is to show the bearing which this upheaval has upon the prospect of finding Coal in the Eastern Counties, and especially at Hunstanton and along the outcrop of the Kimmeridge Clay. Its effect obviously is to bring the Palæozoic strata proportionately nearer to the surface; but as the intermediate beds between the Cretaceous and Palæozoic are an unknown quantity, and may be of such a thickness as to preclude the possibility of reaching coal at a workable depth, I propose to set before you the grounds on which I have arrived at an opposite conclusion. I will call your attention to other borings besides those at Yarmouth and Norwich, mentioned in my last paper. First to that at Kentish Town, London, which is described by Mr. Prestwich (Quart. Journ. Geol. Soc., February, 1856, and in his Report "On the Probability of finding Coal in the South of England," Vol. I, page 149, Coal Commission). In 1854-5, he says, a boring was made on the north side of London in search of water through the Tertiary strata and the Chalk to a depth of 1,302 feet. Instead of meeting, as was expected, with the Lower Greensand, which crops out from under the Gault, both to the north and to the south of London, certain red sandstones, probably of the Palæozoic age, were met with. The following section was thus obtained:—

Well Shaft and Boring at Kentish Town.
Surface ground, 180 feet above the sea level.

		FT.
Tertiary	London Clay	236
	Sands and Mottled Clay	88½
Secondary	Chalk and Chalk Marl	645
	Upper Greensand	14
	Gault	130
Palæozoic	Red and grey sandstones	188
		1,302

As there is a difference of opinion respecting the age of the red and grey sandstones, and it is desirable to avoid whatever may be considered doubtful or conjectural, I will pass on next to the boring at Harwich, where there can be no doubt the Palæozoic rocks were reached at the depth of 1,025 feet beneath the sea level. We are indebted to Mr. Prestwich also for an elaborate account of this boring (Quart. Journ. Geol. Soc., December, 1857, and Coal Commission, idem).

Section of Well Boring at Harwich.

		FT.
Tertiary	Earth and gravel	25
	London Clay	23
	Sands, shingle, and Mottled Clay	28½
Secondary	Chalk	888
	Upper Greensand	22
	Gault	39
Palæozoic	Dark slaty rock	44½
		1,070

After passing through the Chalk, and finding the Upper Greensand well marked and in regular order, and then the Gault, but in diminished thickness, the workmen came, at the depth of 1,025 feet, to a mass of strata denoted as a black slaty rock. The specimens brought up by the boring tools consisted of cylinders about three inches in diameter, which break so as to show the lines of bedding or of cleavage, or possibly of both. Allowing for the smallness of the specimens and the difficulty of very exact determination, it seems probable that these two planes may possibly be one of dip, about 55°, and the other a rough cleavage plane of about 84° to the horizon.

"Of the direction of the dip," Mr. Prestwich says, "I have no evidence. The overlying beds themselves have not an unimportant dip of about 9° southward." This is, no doubt, of great importance, because, on the principle laid down by William Hopkins, this slight dip of the upper beds is an indication of the direction, if not of the amount, of the dip, also of the Palæozoic rocks.

The fact that the Harwich boring did reach these rocks was confirmed by the discovery of the impression of a *Posidonomya* upon a specimen of the slaty rock brought up at the depth of 1,050 feet.

I will next call your attention to a boring at Calais which furnished similar results.

Section of the Boring at Calais.

	FT.
Sands and Gravel	80
Tertiary Strata	161
Chalk and Chalk-Marl	762
Upper Greensand?	3
Gault?	26
Carboniferous Strata	106
	1,138

It appears, therefore, that under the central part of the London Tertiary area, and extending into France at Calais, there is a tract or ridge of the older rocks, which immediately underlies the Chalk and the Gault; and on different parts of this tract the wells of Harwich and Calais, and most probably that of Kentish Town also, have touched.

A question then arises, what is the nature and quality of the coal reached at Calais? It is admitted on all hands to be identical with that of Belgium, and the objection raised by Sir Roderick Murchison that it thinned out as it ranged from Belgium to England, is satisfactorily removed by Mr. Prestwich, who has shown that the thinning out is the effect of denudation, and affords no proof of any deterioration or dying out of the measures, or approach to old shore lines.

Another question arises as to the course which the Coal Measures take from France and Belgium to Somersetshire, or, in other words, the direction of the great anticlinal from the Ardennes to the Mendips.

In reply to this question Mr. Godwin-Austen, has recourse to the soundest principle by which unseen and hidden subterranean movements can be determined. He states that a good many years ago, at the meeting of the British Association at Southampton, Mr. Hopkins, who had attended a great deal to that subject, then remarked that he thought it was a generalization in which he (Mr. Godwin-Austen) was justified, that "every disturbance has been upon the line of a previous disturbance, and that it has always gone in the same direction ; there was upheaval where there was upheaval before, and depression where there was depression before" (Coal Commission, Vol. II., page 431), and in the preceding page he states that "engineers are now quite satisfied that surface features are guides to what long antecedently has taken place below ; and the reason is this, that the original set of disturbances which affected the old Palæozoic strata have always been the line of subsequent disturbance, and are actually the hinges, as it were, upon which these rock masses have moved since ; and these rocks record these original physical lines in the disturbances which have taken place since."

Taking this principle for his guide, Mr. Godwin-Austen traces the line of the Franco-Belgian Coal Measures along the valleys of the Thames and the Kennet, and keeping the results of the borings at Calais and Harwich in view, he arrives at the following conclusions (Coal Commission, Vol. II., page 432):—"At Harwich you have most certainly a low part of the true Carboniferous Series, and that adds considerable weight to the consideration that a productive coal-bed may occur in the south-east portions of this country. I have no doubt that between Harwich, where you have this Posidonomya-schiefer Series, and our north Wealden escarpment, which here represents the Boulonnais escarpment, and both which are in strict parallelism with the strike of the old Palæozoic rocks, the whole of that area which underlies the Chalk is Palæozoic of different ages, from one part to another; and the only question is in what part is it Carboniferous. In Belgium, upon the meridian of Mons, rocks much older come hard upon the coal-basin of the south ; but we also see all the members of the Carboniferous Limestone series spreading out west; and this identification of the

Posidonomya-schiefer at Harwich is in exact conformity with the line upon which you would place it; it is the very position where you would expect some part of the Lower Coal Measures to exist from the geological structure of central England, and North Belgium, and Westphalia. If such is the case, it is almost impossible to resist the impression that in some intermediate position, as along the line of the Thames Valley, you have a continuation of the Belgian and French coal-basin, passing along in a western direction ; I mean that you have an extension of the coal-field of the Pas de Calais. If I have rightly restored these conditions conjecturally, the coal beds would occur beneath our area to the north of the Kentish Chalk range, extending out here in a westward direction, and the productive beds would thicken in the county of Kent, that line representing the strike of the supposed coal basin. Were I a Kentish or Essex landowner, I should be very much disposed to sink along a line parallel to the Chalk escarpment of Kent to the north east of it."

It would be a matter of surprise to me, and of extreme regret if the opinion of so distinguished a geologist as Mr. Godwin-Austen, who has devoted himself so many years to the subject, were not acted upon. It is true that his views have not been unanimously supported by scientific men, and that objections have been raised by one no less eminent than the late Sir Roderick Murchison, but they can scarcely be said to be adverse since they amount merely to a question as to the thickness of the seams and the quantity, and not to the existence of coal on this side of the French coast, and they have been satisfactorily replied to by Mr. Prestwich in his report on the Coal Commission as above mentioned.

I am convinced of the soundness of Mr. Godwin-Austen's views, and, therefore, in recommending an experimental boring for coal in the Eastern Counties, I give the preference to South Essex over Hunstanton and the outcrop of the Kimmeridge Clay; but at the same time I am so strongly impressed with the probability of finding coal at the above localities that I will proceed to state the reasons why I should recommend a boring there also.

The subject will, I think, be rendered most intelligible if I trace the progress of my inquiries from the commencement to the present time. I began to break the ground at the meeting of the British Association at Nottingham in 1866. The following is a brief abstract from the "Athenæum" of September 8th, 1866, of a paper read by me "On the Anglo-Belgian basin of the Forest-bed of Norfolk and Suffolk, and the union of England with the Continent during the Glacial period:"—"A question of the greatest importance had been raised by Mr. Godwin-Austen with reference to the extension of the Belgian Coal Measures into this country. It was evident that, at the close of the Mesozoic period, the continuous ranges of Chalk in Belgium, France, and England formed a basin in which Tertiaries were deposited. The writer of the paper, after researches carried on for upwards of thirty years, had come to the conclusion that the Forest-bed was the estuarine deposit of some 'great river' or rivers flowing westward, closed on the south by a ridge of Chalk hills and open to the sea on the north, as was proved by the mixture of the bones of whales with those of land animals; and that such ancient river or rivers were now represented by the several rivers flowing into the German Ocean between the mouths of the Scheldt and the Rhine. Thus there might be said to be on the English coast the remains of an estuary without a river, and on the Belgian side of a river or rivers without an estuary. After describing the deposits of the elephantine and other remains, which indicated an immense period of time, and several alternations of levels, the reverend gentleman stated his impression that the Forest-bed and the Crag-series could only be studied with advantage in connection with and as part of the corresponding beds of the Continent. A very animated and rather lengthy discussion arose upon the questions raised in this paper. The President said he began to strongly suspect that even the valley of the Thames might be filled with Glacial Drift, showing that it was submerged during the Glacial period."

Such is a sketch of my attempt to describe the Anglo-Belgian basin and the changes of levels incident to it. Judge, then, of my surprise on reading a paper by Sir Roderick Murchison at the same meeting to find that Norfolk and Suffolk, the site of the Forest-bed, were included within the tracts in which "no productive coal could reasonably be looked for."

Fully impressed with the soundness of the axiom respecting the repetition of subterranean disturbances on the same spot, and of its applicability to the Anglo-Belgian basin, I read another paper at the meeting of the British Association at Brighton, the purport of which was to show that the site of that basin had been alternately dry land and water, and had been occupied by a succession of them from the earliest times. In support of the existence of this basin, I referred to the correspondence of the strata on both sides of the estuary, and I stated that the old Forest grew upon the estuarine soil when it was upraised, and when it went down the denudation of the Forest commenced, and patches of lignite were left. One of these was noticed by Mr. Henry Woodward, F.R.S., in an excursion with me to Happisburgh, who observed that such lignite would, under favourable conditions, be converted into coal. I mentioned this as a repetition of what has taken place, and there can be little doubt did take place during the Carboniferous epoch in a similar basin.

Beneath the Forest-bed, it may be proved, the Chalk and other members of the Cretaceous series successively have been deposited in the same basin, but more extended. Again, it, or the margin of it, was occupied by Palæozoic rocks, including the Posidonomya-bed of the Carboniferous Limestone at Harwich. Sir Roderick Murchison contended that, because the coal seams thin out, as he erroneously termed it, near the Pas de Calais, that, therefore, they cannot be productive of good coals on this side of the water. He was impressed with the idea of the continuity of the older rocks and the dying out of the coal seams, and overlooked the probability of coal-bearing basins intervening between the two countries. That a basin exists and has existed since the period of the Carboniferous Limestone, and has been subject to repeated elevations and depressions, cannot be questioned. Arguing by analogy, Mr. Gunn observed it appeared highly probable that such was the case when the Harwich slaty limestone might have formed one of the sides of the basin. It appeared, therefore, taking all these facts into consideration, that Norfolk and Suffolk should be excepted from "the tracts of land in which no productive beds of coal can reasonably be looked for."

On sending this paper in, I had begged the attention of the members to it, and I felt grateful both to those who opposed and to those who supported my opinions.

In a lengthened discussion, Professor Hull most decidedly expressed his opinion that no coal could be expected to be found in Norfolk and Suffolk, and he stated that there was little doubt that the Harwich Carboniferous Shales were to be looked for towards the south, and not in the direction of Norfolk, over which district he affirmed there had extended from

Scandinavia, a tract of barren Palæozoic rocks, which would not have admitted of coal-growth. Professor Phillips also most decidedly discouraged any attempt to bore for coal in Norfolk, but said that no one knew the direction of the dip of the Harwich slaty rock, and that he did not coincide with Professor Hull as to the extent of the Palæozoic unproductive rock. The President of the section, Mr. Godwin-Austen, observed, " as to the probabilities of finding coal north of the axis of disturbance, he would mention that it was there in that direction that all the coal-fields lay. The question of the overlying Secondary rocks, as at Hunstanton, was no argument against the extension of the Coal Measures. With regard to what Professor Hull had said concerning the dry land area of Scandinavia, and the Eastern Counties, he could not altogether assent to it. . . If the Norfolk people desired to have a boring, they ought not to discourage them. Everything depended upon the ancient physical geography of the area . . . He thought it possible there might be a continuity between the central coal-fields and East Anglia: one thing he was thoroughly convinced of, that at no distant period considerable areas of coal would be worked under the Secondary strata."

Mr. Seeley made a very telling and important statement, which was opposed to Professor Hull's sweeping assertions that no Coal-growth could have taken place in Norfolk, namely, that pebbles of Primary rocks were found in the Secondary strata of Norfolk. This indicated that the ancient surface had been denuded, so as to lessen the chances of finding Coal, but it rather affirmed that Coal had originally been deposited there.

Several years before reading this paper at Brighton, I had noticed the inclined plane of the Chalk in Norfolk, upon which the several beds of the Forest and the Crags, and the Chillesford Sands and Clays, had been transgressively laid down, and upon which the *Mastodon arvernensis*, *Elephas meridionalis*, *E. antiquus*, and other mammals had lived in succession; and my former paper was accompanied with a diagram, which I had prepared for and had exhibited at the meeting of the British Association at Norwich. But it was only recently that I became aware of the important bearing which this upheaval of the Chalk had on the prospect of finding coal in Norfolk at a workable depth. In consequence of this conviction, I sent a paper to the meeting at Bradford, the object of which was to show that the Coal-Measures, if they existed at Lynn (for I traced the dip of the Chalk from that place to

Yarmouth), had been brought at Lynn nearer to the surface by the amount of the upheaval.

This is not a matter of conjecture or of theory, but of fact and demonstration; and a more important fact in an economical as well as geological point of view can scarcely be conceived. The result of this is that if the Coal Measures at Hunstanton, or anywhere near the outcrop of the Kimmeridge Clay, were as deep as they have been calculated to be in Lincolnshire, viz. 2,700 feet, they have actually been brought nearer to the surface by about 1,700 feet, and would be within a workable depth. It appears to me from Professor Phillips' remarks, that he did not so much found his objection to the contemplated boring at Hunstanton upon the presumed absence as upon the depth of coal there, and, therefore, I may hope for the concurrence of that veteran geologist.

Again, another most important result is that this upheaval of the Chalk affords a complete refutation of Professor Hull's assertion, that the Eastern Counties were covered by Palæozoic barren rocks during the Carboniferous epoch, from which no coal growth could be expected. He (Mr. Hull) arrived at this conclusion by observing that the dip of the Harwich slaty rocks was most probably to the south, and if so, he concluded that these old rocks rose to the north, and were incapable of coal growth. Now it is proved by the boring at Norwich that the Palæozoic rock must be upwards of 100 feet lower than at Harwich, and the Gault was not pierced when the boring reached 1,182 feet, consequently the old rocks at Norwich would have been much lower than at Harwich, instead of rising, as Professor Hull supposes, so as to form a high and dry surface upon which no coal growth could have taken place. Perhaps this difficulty may be solved by supposing that there was another anticlinal ridge parallel to the Thames, of which the Harwich rocks formed a part, and so the dip to the south might be accounted for, and also to the north, forming a margin to the basin on the other side, which I have inferred by analogy to have existed from time to time.

Another very interesting result is that the Palæozoic rocks have at times been raised above the horizon, and at other times depressed in accordance with the alternations of level, which we have noticed, and being covered with only a slight envelope as it were of Secondary and Tertiary strata, would have been acted upon by subterranean movements which have repeatedly taken place. This is just what appears to have been the case, judging by the frequency of small faults in the Crags and the disruption and the displacement of the Chalk and contortion of the sand and clay. These, I am persuaded, from personal observation of similar contortions at Corfu, in the Eifel district, and in Savoy, are not altogether to be attributed to ice action, but are due to subterranean movements near the surface. I hoped to have been prepared with sections to prove the point, and I trust I may be permitted to submit them to the Geologists' Association at some future time. In the meanwhile, as I am suggesting what is at variance with the received opinions of some, and have not entered into those of others, all I can request

CORRIGENDA

To the Rev. A. Irving's Paper "The Geology of the Nottingham District."

(Proceedings of the Geologists' Association, Vol. IV., p. 45).

Page 53, line 2, for *reference* read *inference*.

Page 55, line 25, for *Coal Measures and Permian* read *Permian and Trias*.

progress there. Professor Hull has rendered good service by observing the gradual thinning out of the Secondary strata in their progress eastward; but the same story is told with infallible certainty by observation of the dying out of beds as they approach to higher land or a shore line, and the presence of higher land may be inferred by the thinning out of the aqueous deposit.

In conclusion, I must apologize for so often referring to my own works, but I am glad to do so in self-defence in order to prove that I have not taken upon myself to recommend a boring for coal in the region of the Forest-bed rashly and without much consideration; and also I hope I have been enabled to make a complex subject more intelligible by showing how, step by step, I have advanced in search of coal; and, I trust, I may be still further allowed to avail myself of the indulgence of the Geologists' Association to promote the object I have in view.

2. THE GEOLOGY OF THE NOTTINGHAM DISTRICT.—PART I.

By THE REV. ALEXANDER IRVING, B.A., B.Sc., F.G.S., &c.

The district which lies around Nottingham, and occupies the southern half of the county of Nottinghamshire, is one which, though devoid of much palæontological interest, is yet by no means uninteresting in other respects; presenting, as it does, many questions of physical geology, and especially stratigraphical evidence as to the relation of the rocks which occupy the borderland between the Palæozoic and Mesozoic epochs. If therefore the following paper deals at all competently with the subject, it may not be altogether unworthy of perusal.

A glance at a geological map of England will show anyone that, within a short distance of Nottingham, are to be found Coal Measures with Permian, Bunter, Keuper, and Lias rocks. The general lie and position of these formations may be readily seen from the accompanying figure (Fig. 1), in which, however, the actual dip is somewhat exaggerated. I propose to take the several formations singly, and describe, to some extent, their lithological characters and economic importance, together with the physical geography of the country occupied by each; noticing, to the best of my power, any questions of general geologic interest on which the phenomena here presented may seem to bear.

COAL MEASURES.

One of the most important coal-fields in England is that which occupies a great part of the counties of Yorkshire, Derbyshire, and Nottinghamshire. Extensive, however, as it is, it forms but a portion of the great coal-area in which it was originally deposited. The identity of its coal-seams with those of Lancashire, and the conformability of the coal strata to the Lower Carboniferous rocks on both sides of the Pennine axis of upheaval, point conclusively to the former continuity of the Coal Measures over the Carboniferous Limestone, Yoredale Series, and Millstone Grit of the present Pennine chain of hills. All these have long since been thrown up into an anticlinal, so as to bring, by fracture and denudation, the Carboniferous Limestone, in many parts, to the surface; one result of these processes being presented to us the well-known dales and escarpments which add so much to the picturesqueness of the

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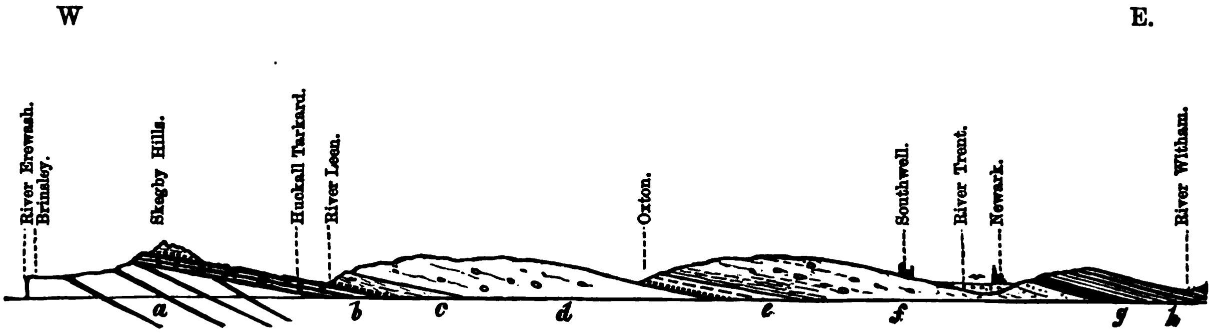
FIG. 1.

HORIZONTAL SECTION OF THE STRATA OF SOUTH NOTTINGHAMSHIRE, FROM THE EREWASH TO THE WITHAM.



~ Alluvial deposits of the Trent Valley.
h. Lower Lias, Clay, and Limestone.
g. Rhaetic Beds.
f. Upper Keuper: Gypseous Red Marls with local beds of Sandstone.
e. Lower Keuper: "Waterstones."
d. Bunter Conglomerates and Pebble-beds.
c. Lower Bunter: Red and Mottled Sandstone.
b. Permian Strata: Magnesian Limestone with Breccia, Marls, and Sandstones.
a. Coal Measures, unconformable to the Permian strata.

Derbyshire scenery. While the Millstone Grit and some of the Yoredale sandstones, by their greater power of resistance, have stood out in bold escarpments, the Coal Measures, being composed generally of less rigid material, have suffered to a greater extent from denudation. In consequence of this, the valley of the Erewash—the boundary stream between Nottinghamshire and Derbyshire—has been formed. On the western side of this valley the Millstone Grit is found dipping eastward beneath the Coal Measures; on the eastern side of the river the surface of the ground gradually ascends until the Permian escarpment is reached This, of course, commands a wide view of the Nottinghamshire and Derbyshire coal-field, from the Trent Valley on the south to Ilkeston and Chesterfield northward. The Coal Measures, by passing under the Magnesian Limestone, disappear from the surface.

The seams of any economic value at present, which crop out in this valley, are seven in number:—

1.—The "Top-hard" coal.
2.—The "Waterloo" coal.
3.—The "Deep-soft" coal.
4.—The "Deep-hard" coal.
5.—The "Three-quarter" coal.
6.—The "Clod" coal.
7.—The "Kilburn" coal.

These, of course, are local names, by which the seams are known to persons engaged in mining operations in the district. I am not aware that the names are generally used: indeed, one of the most important seams—the Top-hard—is known in Yorkshire, I believe, as the "Barnsley" coal. Below the Kilburn is a series of comparatively worthless seams, which, with their associated sandstones and shales, are known as the "Ganister Beds." This basin appears to have been part of a great coal-area, extending originally from the old land of Charnwood to the sourthern uplands of Scotland, broken up subsequently into separate basins by two east and west barriers; the one running, according to Professor Hull, across the Pendle axis of elevation, and consequently cutting off the Newcastle basin from ours; the other, according to the same authority, extending from Denbighshire beneath the Plain of Cheshire, by Leek and Congleton, across the southern end of the Mountain Limestone district of Derbyshire, with a south-easterly trend in the direction of Charnwood. A subsequent upheaval along the Pennine axis cuts off the Nottinghamshire and Derby coal-field from that of Lancashire. Now, assuming with Mr. Godwin Austen and other eminent physical geologists, that during the Old Red Sandstone and Carboniferous periods, the Palæozoic country of Wales was connected by a "barrier," running somewhere across England by the Longmynd and Charnwood, with an old land surface which extended over what is now a great part of the German Ocean in the direction of Scandinavia—have we any indications of the limits of the extension of such an old continental tract in a north-westerly direction? Professor Hull has indicated, on a map constructed to illustrate his work "The Coal-fields of Great Britain," that the limit of the estuarine area—or, in other words, the shore-line of the old land we are now considering—was in a curve drawn from Charnwood to the Humber, so as to include Newark and Lincoln; but is this anything more than conjecture? That the Coal Measures pass a long way beneath the Permian and Triassic rocks is pretty certain. Do they, however, thin out as they proceed eastward? or do they curve upwards again, so as to form a synclinal basin, and be found at a workable depth on the borders of Lincolnshire? Mining engineers have detected sufficient diminution in the general dip of the coal strata, going east from the Erewash Valley, to warrant expenditure of money upon a "boring" near Newark. Should the Coal Measures be found there at a depth which can be approximately estimated from the known thickness of the Triassic and Permian strata, we shall of course be furnished with some definite data for forming a judgment upon the extension of the coal-basin in that direction; but should they pass from the Permian or Bunter rocks into rocks of earlier Palæozoic times than the Coal Measures, we may infer with confidence the thinning out of the latter strata somewhere to the west of Newark. There is yet a third question, and, on a broad view, perhaps the most interesting of all. Professor Hull states,* on the authority of Mr. Howell, of H.M. Geological Survey, that the axis of the elongated basin in which these coal-strata lie, is represented by a line running north-west and south-east, through Bradford and Worksop; and this is corroborated by the ascertained thickness of the Upper Coal Measures at the Shire-oak Colliery, near Worksop. The pit was sunk by the Duke of Newcastle in 1859, and a description of it was given in a paper read before the Geological Society, and published in Vol. xvi. of the "Quarterly Journal." After passing through 207 feet of Permian strata the Coal Measures were entered:—

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* Professor Hull: "Permian and Triassic Rocks of the Midland Counties."

	Feet.
1.—Upper Coal Measures to the "Top-hard" or "Barnsley" coal, including numerous sets of beds of shale, sandstone, and inferior coal (the "Rotherham Rock" being there 66 yards in thickness)	1300
2.—Estimated thickness below the "Top-hard" seam.	2000
	3300

This gives us the thickness along the axis of our conjectural synclinal basin. On referring to the map it will be seen that, if the line, imagined to pass through Bradford and Worksop, be continued to the south-east, it passes very near Newark. Who can say, then, that some 1,300 feet of Upper Coal Measures may not be pierced before the Top-hard seam is reached at the latter place, assuming the seam to extend so far? And, should this prove to be the case, who can say how much farther the Coal Measures may not extend in the direction of Norfolk? On the other hand, it must be borne in mind that the thickness (3ft. 10in.) of the Top-hard coal at Shire-oak, as compared with its known thickness (6ft.) at Killamarsh, at Wilford, near Nottingham, and at Moorgreen, in the Erewash Valley, implies a thinning-out of that seam to the north-east.

As we pass eastward along the southern limit of the Nottinghamshire coalfield, the dip trends more to the north. But, since this is caused by the great fault which runs east and west, it gives us no indication of the limits of the coal-strata to the south. That coal exists at a workable depth beneath the valley of the Trent, near Nottingham, has been proved at the colliery of Saul Isaac, Esq., M.P., at Wilford. Here the Top-hard coal is met with at a depth of 70 yards; but on the south side of the shaft the fault just mentioned has thrown the beds down another 95 yards. In consequence of this displacement, at a boring nearer to the village of Clifton (at what is known as the "Spinney bore-hole"), the same seam is only reached at 186 yards. A comparison of this boring with the Wilford shaft is the more interesting, because, in order to account for the difference of 21 yards in the depths at which the same seam is found at the two places, we must assume the eastward extension of the fault marked hypothetically on the survey map as running south of Bramcote and through the village of Beeston. By the continuance of such a fault between Wilford and Clifton, the difference of the two borings just referred to seems to be accounted for. This fault has been shown, too, to exist by two other borings in the same neighbourhood, and both in the Trent Valley: the one at Chilwell; the other at Highfield, on the estate of E. J. Lowe, Esq. At the latter place, Coal Measures were entered after penetrating 25 feet of gravel and alluvium, and, below these, nearly 100 feet of Bunter strata. A coal-seam has been cut here at a depth of 254 feet. The Chilwell boring, after penetrating to a depth of 336 yards, was abandoned, owing to some dispute between the proprietor and the manager. A considerable thickness of rock (described in the account furnished me as Keuper) was pierced below the alluvium of the valley, and the Coal Measures are stated to have been entered at the depth of 156 yards. Deducting from this five yards of alluvium, we have left 151 yards of Triassic strata to compare with the thickness of the same strata at Highfield; and the difference is such as can only be accounted for by the fault above referred to, which must have a down-throw to the south. Four seams were cut at the Chilwell boring, of the respective thicknesses of 6, 17, 12, and 9 inches.

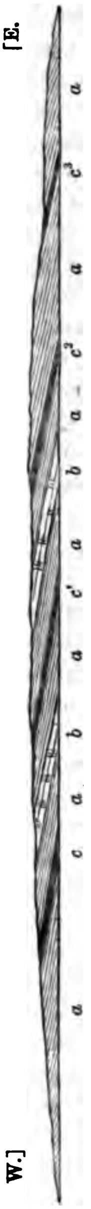
In dealing with a subject on which so much has been written as that of our coal-fields, it is difficult to say much that is new without descending too much to details. It is hoped, however, that some little interest may be found to attach to the above.

The recent high prices of coal have proved a great stimulus to the spirit of mining enterprise among capitalists, and a number of new pits have been sunk in consequence in the neighbourhood of Nottingham, partly to meet the demands of the manufacturing industries of the locality. The pits now in working order within ten miles of the town are too many to enumerate. The great increase of trade, of population, and of mineral traffic of late years has also created a necessity for more railway accommodation; and at the present time two new railways are being constructed across the coal country: one by the Great Northern Company, to pass round by a sweep to the north of Nottingham, and open up communication between the mineral districts of Derbyshire and the Eastern Counties; the other by the Midland Company, in a line due west from Radford, on the western side of Nottingham. The latter runs parallel with the Nottingham Canal, and in one place close by it, suggesting rather forcibly the contrast between the requirements of the present day and the slow-going transit, by means of locked canals, which sufficed only a generation or two ago. This railway has exposed, in a cutting at Wollaton, no less than four seams of coal, within a distance of about 300 yards. They have an easterly dip of about 5 deg., and crop up at the surface of the ground, thus—(Fig. 2). In the pit sunk here by Mr. Oldknow, of Nottingham, the flow of water is so great as to necessitate the "tubbing" of the shafts with iron for about 100 yards.

Not only in the country where the Coal Measures come to the surface, but all up the Leen Valley, where twenty-five years ago the Magnesian Limestone was penetrated by a single pit — that at Cinderhill—tall chimneys rear themselves in all directions, disfiguring the landscape, and accompanied by all the usual disagreeables of coal-mining. Even the Bunter, which lies upon the Permian on the east side of the Leen, and in its northern part extends round to the west of that river, forming the Skegby Hills, is pierced by a pit extensively worked at Annesley. Another is about to be sunk through the same strata east of the Leen, on the north side of Bestwood Park. On referring to the report of the proceedings of the British Association at Nottingham in 1866, I find that the late Director-General of the Survey, in a paper read by him on that occa-

Fig 2.

SECTION OF COAL MEASURES IN THE RAILWAY - CUTTING AT WOLLATON.



c^2, c^3. Coal-seams of inferior quality.
c'. "Soft" or "Comb" Coal (not worked).
c. Top-hard seam, shown at its outcrop on the Survey-map.
b, b. Thick-bedded Sandstones.
a. Clunch and Shale.

sion, referred to some statements which he had made three years before, in a lecture given at Mansfield, to the effect that it was even then well known that betweeen Mansfield and Nottingham "the Derbyshire coal-strata, rich as they are, *become thicker and thicker as they dip under the Magnesian Limestone* . . . . and produce coals, superior indeed in quality and dimensions, to most of the beds of Derbyshire, where no one, even a few years before, *except geologists*, thought of their existence." And Sir Roderick predicted that a future rise in the price of coals would lead to mining for them even under the New Red Sandstone, though at depths which would then have rendered such operations unremunerative. This is now going on. I have taken the liberty of italicising a portion of the above passage, because, from some misapprehension, it appears, of what the veteran geologist said on the subject, certain "practical" people fancy that they have since proved him to have been in error by bringing to light facts, which simply, so far as I can make out, corroborate his statements.

THE POIKILITIC SERIES OR SYSTEM.

This term has been restricted of late years by some geologists to the Triassic rocks; but when one finds so venerable an authority as the late Professor Phillips,—who himself anticipated Murchison's "Permian" nomenclature, by a proposal to correlate the Magnesian Limestone and its associated marls and sandstones with the rocks of the Carboniferous period, "on the *ground of the fossil contents*"—asserting, as the result of further study, that "in some respects and in some districts it is more convenient to adhere to the old-established alliance of the Permian many-coloured deposits, with the variegated sandstones and clays of the New Red series," I trust I may be acquitted of any charge of presumption or conceit, if I do not hesitate to treat at least the Permian and Bunter as a continuous series, whose "*physical history* on the whole is one great sequence of natural operations." And although feeling necessarily somewhat diffident with regard to my own interpretation of the facts which I have observed, one cannot err greatly in applying the principle recommended by such a master of geological science—"to adapt our classification to the region which specially engages our attention for local description and limited reference."*

PERMIAN.

The Magnesian Limestone is by far the most important member of the Permian group in Nottinghamshire. Further north, beyond Mansfield, it produces the beautiful crystalline dolomite, which furnishes a building stone of great durability, except when exposed to an atmosphere like that of the metropolis, where the enormous consumption of coal and coal-gas charges the air with sufficient sulphur dioxide to effect the same sort of metamorphosis as that which takes place in a carbonate underground, when exposed to the water charged with the same gas from the oxidation, it may be, of iron pyrites or of native sulphur. Near that town, too, are the fine intercalated masses of a much more siliceous character, well known to architects and builders as the "Mansfield White" and "Mansfield Red" sandstones. As we proceed south, in the direction of Nottingham, the Magnesian Limestone assumes smaller proportions, though a coarse granular variety is quarried at Bulwell, and extensively employed in Nottingham and the vicinity for public buildings. The Permian series about Nottingham belongs mostly to the "Zechstein" group, the "Kupferschiefer" is partly represented, while the "Rothliegende" appears to be wanting altogether. The series thins out and disappears along a line running east and west between Wollaton and Bilborough, not, I think, as the result of subsequent denudation of the series itself, but of the previous denudation of the Coal Measures on which it rests. The marls lie chiefly above the principal beds of Magnesian Limestone, and are themselves interstratified with thin flaggy bands of that rock. The uppermost beds are the Permian Sandstones, which at Cinderhill have their planes of bedding commonly marked with annelid-tracks. At Kimberley an interesting fault, which has brought up the Coal Measures to a level with the Magnesian Limestone, is now exposed in the new railway cutting. The character of the Permian strata varies very much horizontally, even within very limited areas. Thus at Cinderhill, about three miles from Nottingham, the section represented in Fig. 3 is to be seen, with the Permian Marls well developed, and (where not removed for bricks) resting upon the Magnesian Limestone, while the Sandstones in turn rest upon the Marls.

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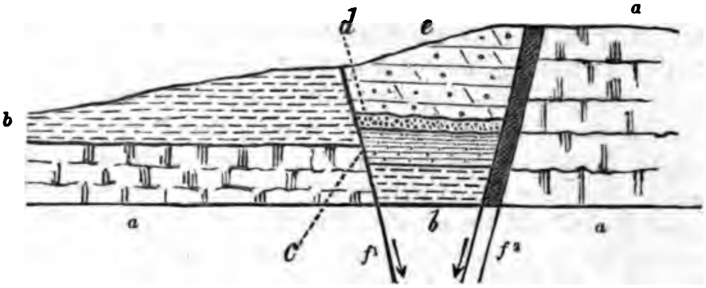
* "Geology of Oxford and the Valley of the Thames," by John Phillips, p. 88.

FIG. 3.

SECTION AT CINDERHILL BRICK-YARD NEAR NOTTINGHAM.



a. Magnesian Limestone.
b. Red and purple Marls with thin bands of Limestone.
c. "Permian" red Sandstones.
d. Breccia Bed.
e. Lower Mottled Sandstone, much less coherent than *c.*
f^1. Fault, with downthrow to the right of 10 feet.
f^2. Fault, with downthrow to the left of 40 feet.

About half-a-mile to the north a railway cutting, just made through an outlier of Bunter with a Permian base, has exposed the same Upper Permian Sandstones; but here they have thickened, and the Marl has almost disappeared. Near Bobber's Mill (two miles to the S.E.), a variation of the opposite nature is observable: the deposits are much less siliceous than at Cinderhill, and the uppermost Permian strata are composed chiefly of marls At Linby, and other places, the limestone is quarried both for lime-burning and for building purposes. None of the beds here are very thick, and they have distinct marl-partings. At Kirkby we get down to the basement beds of the Permian series, and the Marl Slate is found to yield the characteristic *Schizodus.*

The great *unconformability* between the Coal Measures and Permian is inferred from several facts:—

(1.) The Magnesian Limestone, which at the Shire-oak Colliery is 1300 feet, and at Hucknall Torkard 1100 feet above the Top-hard seam, is seen at Strolley resting immediately upon that seam, whose outcrop must have been exposed at the latter place by denudation *prior* to Permian times; so far, at least, as they are represented by any Permian strata in this district.

(2.) We have proof of a great movement between the Carboniferous and Permian deposits in a most interesting fault at Cinderhill. This fault cuts through the Lower Mottled Sandstone of the Bunter and through the Permian strata, and passes down to an unknown depth in the Coal Measures. It has affected the Bunter and Permian series equally, and to the extent of only about ten yards; but in the Coal Measures, my friend, Mr. G. Fowler, C.E., the engineer to the colliery, has found, by actual measurement, after working up the "hade" of the fault, where it has dislocated the Top-hard seam, that the vertical displacement is no less than 70 yards in the Coal Measures. Two things, of course, are recorded here. In the first place, the fault gives no indication of any disturbance between the depositions of the Permian and Lower Bunter strata. But secondly, when we deduct the displacement of ten yards which the two upper series have suffered from the total displacement of 70 yards, there remains a *throw of* 60 *yards as the result of movements which must have occurred between the deposition of the Carboniferous and Permian strata.*

Now as to the *conformability* of Coal Measures and Permian:—

(1.) The thickness of the breccia which here marks the junction of the Permian and Bunter series varies from one to three feet. In the railway cutting before referred to there is the same sequence of beds (with less marl); the breccia bed is also much thinner. *There is no unconformability apparent at either of these sections between the Bunter and Permian series,* nor, as we have seen, does the fault at Cinderhill give indication of any extensive movement, such as would in all probability have occurred had there been any great lapse of time between the two periods of deposition represented by the two groups now under consideration.

(2.) Mr. E. Wilson, F.G.S., of Nottingham, has made a careful examination of the fragments contained in the breccia both here and at Kimberley, where he has observed it. He describes them as of a most varied character, "nodular and concretionary balls and slabs of Permian limestone, some of them containing cavities lined with calcite, the nodules themselves being often encrusted, and having their surfaces indented, with small angular pebbles, while in other instances they adhere to the surface by a calcareous cement." Mr. Wilson thinks that this affords evidence of the incomplete consolidation of the Permian strata at the time the breccia was accumulating, and that consequently we are justified in relegating it to the close of the Permian times. He has found a good deal of chert from the Derbyshire limestone, as well as fragmentary encrinites, though these are more abundant at Kimberley, which is three miles nearer the source of them. The breccia contains also numerous "fragments of light green and dark blue slate, fragments of purple and drab Permian marlstone, and a few partly rounded quartz pebbles." The breccia appears to rest upon a surface of Permian sandstone, rendered somewhat uneven by contemporaneous erosion; and this, too, would seem to connect the breccia closely in time with the Permian. The same kind of breccia was found at the base of the Bunter, in sinking the shaft of the Wilford Colliery, near Nottingham. Mr. Marsh, the manager, informs me, however, that there were no Permian strata below it. This would seem to indicate that, during the deposition of the Permian strata, those parts of the Coal Measures which were above the sea suffered degradation to such an extent that a slight alteration of level was sufficient to extend the shore-line across both Permian and Coal formations. The absence of Permian strata, too, at Wilford, justifies us in assigning the breccia to the Bunter as much as to the Permian series, and this inference is borne out by its position at Bobber's Mill (a place midway between the Cinderhill and Wilford sections), since here the breccia is found forming the actual base of the Lower Bunter sandstone to the thickness of four to six inches, and resting itself upon very tenacious marls usually assigned to the Permian strata.

The general inference seems to be that the breccia belongs *to the Bunter and Permian series equally*, and, with the *conformability* of the strata above and below it, affords no ground for assuming a great lapse of time between the deposition of the Permian and Bunter deposits.

ORDINARY MEETING, MARCH 6TH, 1874.

Henry Woodward, Esq., F.R.S., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

"Earth Sculpture," by A. Geikie, LL.D., F.R.S., &c.; from the Author.

"The Lead and Zinc Mines of the Mendips," by H. B. Woodward, F.G.S; from the Author.

"Smithsonian Report, 1871;" from the Smithsonian Institution.

"Sixth Annual Report of the United States Geological Survey," by F. V. Hayden; from the Author.

"Quarterly Journal of the Geological Society;" from that Society.

"Abstracts of Proceedings of the Geological Society;" from that Society.

"Transactions of the Manchester Geological Society," Vol. III., Part 2; from that Society.

"Catalogue of the Publications of the Geological Survey of Great Britain."

The following were elected Members of the Association :—

Thomas J. Downing, Esq.; James R. Gregory, Esq.; H. J. Johnson Lavis, Esq.; Horace B. Woodward, Esq., F.G.S., H.M. Geological Survey; J. F. Walker, Esq, M.A., F.G.S., &c.; John Noble, Esq., R.N. (retired); and John W. Wetherell, Esq.

The following Paper was read :—

THE GEOLOGY OF THE NOTTINGHAM DISTRICT.—Part II.

By the REV. ALEXANDER IRVING, B.A., B.Sc., F.G.S., &c.

THE BUNTER.

The threefold division of the Bunter, as adopted by the Survey, into

c. Upper Red and Mottled Sandstone,
b. Conglomerates and Pebble Beds,
a. Lower Red and Mottled Sandstone,

is well known. These seem to have been traced with great precision by Professor Hull in Cheshire. There are, however, no sections in Nottinghamshire, so far as I am aware, which present these three members of the Bunter formation in succession; in fact, the uppermost sub-formation is generally considered to be altogether wanting, or to be represented by the uppermost portion of the Conglomeratic-series. The Lower Mottled Sandstones rest immediately upon the Coal Measures about Wollaton, Bramcote, and Lenton; a fact I think to be accounted for by assuming, that while the Permian beds were deposited in their present area, the denudation of the Coal Measures which had been upheaved to the south and west, was progressing. So that, when a further subsidence occurred at the coming-in of Bunter conditions, a greater extent of Coal Measures was submerged than during Permian times. Had the Bunter and Permian strata been found to be unconformable in this district, a much greater gap in time would have been indicated than we are required to infer from the existing data.

LOWER RED AND MOTTLED SANDSTONE.—This sub-formation does not appear to exceed 100 feet in thickness. It forms an escarpment along the side of the river Leen, between Basford and Radford, where there is very much false-bedding. In one place the strata are thrown into an anticlinal curve, with a slight slip running in the direction of its axis. The beds shewn here are by no means free from angular fragments of slates and grits, though these are scattered somewhat sparsely through the soft sandstone. Further up the Leen Valley, at Basford, the Lower Bunter rocks may be seen by the side of the road, passing gradually up into the Pebble-beds. Here also the former contain a few small angular fragments of slates and grits; "an exceptional case" (according to Professor Hull), but not, as we have just seen, a solitary exception. Wollaton Park lies upon the surface of the Lower Mottled Sandstone. This sub-formation may also be well seen in what is known as "Cut-throat Lane," which leads from Lenton to Beeston. The fault which passes under the alluvium of the Trent, close by the pit of the Wilford Colliery, is supposed to be the same as that which cuts through the banks on opposite sides of this lane. As the result of this fault the Keuper beds are seen lying almost horizontally against a mass of Lower Mottled Sandstone: Professor Hull considered that the position of the marls and thin-bedded sandstone seen here, is about 150 feet above the base of the Upper Keuper series. At the foot of page 97 of his most valuable memoir, "The Permian and Triassic

Rocks of the Midland Counties," that gentleman gives us the following calculation of the *throw* of this fault: —

Keuper.	Red Marl . . .	150 feet.
	Lower Keuper Sandstone	100 „
Bunter.	Conglomerate Beds .	250 „
	Lower Mottled Sandstone	50 „
		550

I was at first inclined to doubt the correctness of the relegation of these marls to the Upper Keuper, since there is nothing in their character which may not be matched by a considerable thickness of marly strata, lying indisputably near the base of the Keuper series, in several sections in the district; and also from the position of a cliff of Bunter conglomerate overlooking the lake in the park of Highfield. On a closer examination of the ground lying between this cliff and the fault it appears, however, that the point at which the fault is shown is somewhat higher than the cliff spoken of, and to the east of that cliff the Keuper strata are found at a considerably lower level. Highfield House stands upon the Red Marl, and an examination of the ground, as it descends to the alluvial plain of the Trent, shows clearly the existence of a fault (with a downthrow to the *north*) between the house and the Bunter escarpment which faces the Trent Valley. From these data it would appear that Professor Hull was correct in assigning the marly strata in the lane to the Upper Keuper. But that these beds are 150 feet above the base of the Upper Red Marls can scarcely be admitted, since, as Mr. Lowe, of Highfield, informs me, the well at his house, when sunk to a depth of 98 feet, penetrated the "waterstones" of the Lower Keuper, and the sinking was arrested by the great influx of water. This shows that the most we can allow for the thickness of the Red Marls against the fault in the lane, is 50 feet, and not 150 feet, as given in the computation quoted above. An inspection of the Bunter sandstones in the lane, against the fault, will enable any one to recognise the signs of a passage into the Middle Bunter series commencing here; these signs consisting in an alteration of the texture and hardness of the rock, and the occurrence of pebbles in it; characters by which it would appear to be assimilated more with the pebbly series above, and which cannot be observed in the rocks of the several undoubted sections of Lower Bunter, which may be seen between this spot and the Leen. I believe, therefore, we must deduct the greater part of the 50 feet which Professor Hull has assumed to have been removed by denudation from the Lower Bunter on the up-throw side of the fault. These two deductions reduce the computed displacement from 550 feet to about 400 feet. A mile to the west of this point, however, as Professor Hull has pointed out, a "certain depth of the conglomerates is seen lying against the Lower Keuper," from which he calculates 300 feet to be the amount of displacement at that place.

This led him to the conclusion that the *throw* of the fault decreases westward to the extent of more than 200 feet in a mile. We have seen, however, that the decrease really required is only about 100 feet. Recently another piece of data has been furnished in the working of the Wilford Colliery. The main shaft here is very near the probable extension of this fault, and its throw has been proved to be, at this spot, a mile and a quarter to the east, only 95 yards. This agrees nearly with Professor Hull's estimate of the throw, a mile to the west of the lane in which it is exposed. Consequently we have *in both directions* the same diminution of throw to the extent of about 100 feet, within a mile or so of the point where the fault crosses the lane. How is this to be accounted for? Not by any great dip of the strata, for there are no indications of this in the escarpment which runs along by Lenton, facing the Trent Valley. The only explanation seems to be the presence of the fault above described as passing through Highfield Park, between the house and the lake, which takes the form of a curve, and runs into the great east and west fault at two points, each within a mile of the point were it is seen in the lane. This also indicates about 100 feet as the amount of the throw of this curved fault, the downthrow being northward, and *towards* the great fault.

No indication is given on the Survey map of the existence of this minor fault, nor of the strip of Bunter which runs along the park and faces the Trent Valley. If we trace the fault westward, it will be seen to have had a principal share in determining the configuration of the country and the nature of the scenery. To the north it has brought up the Coal Measures all along the southern boundary of the Derbyshire and Nottinghamshire Coalfield—at least of so much of it as has the Coal Measures at the surface. Wollaton Park is composed of Lower Bunter, which lies immediately upon those strata. About Stapleford and Bramcote the displacement is still very considerable; for although Stapleford and Bramcote Hills overlook the Coal Measure plain which stretches away to the north, the Coal Measures in immediate contiguity with the fault are so low down in the series as to be some distance below the outcrop of the Top-hard seam, while the outcrops of the Deep Soft and Hard seams (which at Wilford are worked at a depth of 270 yards) terminate against the fault at the foot of Stapleford Hill. This Hill and Bramcote Hill are separated by a rather deep valley, evidently formed by the erosion of the Bunter; the main mass of these two hills being of Lower Mottled and Red sandstone, while they are both capped by pebble-beds. These must have afforded a good instance of the extreme variability, even within short distances, of the power of resistance to denuding agents of the rocks of this formation; for while the valley under consideration has been scooped out, the hills stand out boldly, Bramcote Hill, with its densely-wooded slopes and summit, forming the most conspicuous feature in the landscape in this direction, as viewed from the high ground about Nottingham.

The hill on which the village of Bramcote stands is composed of Bunter capped by Lower Keuper marls, which could not be distinguished by anything but their unmistakeable position from the deepest red marls of the upper division of this formation. As one ascends the hill from the toll-gate, the Bunter rocks are seen in the roadside; but on approaching the summit of the hill these disappear, and give place to the Red Marls. The old church, of which the tower still stands, was built on the highest point of the hill. Of course if its builders had had the light of geology to guide them they would not have chosen the spot which they selected, and so have had to learn from experience what may appear an anomaly to many still—that the top of the hill is damper than a place half way down its slope, where the modern church has been erected. The Bunter extends in a broad band of high ground eastward from about Bramcote to beyond Beeston, when it becomes restricted by the fault described above into a narrow belt that skirts Highfield Park.

One of the most interesting features in the landscape about Bramcote is a rock which stands on a minor hill on the north side of the valley, that has been described as separating Stapleford Hill from Bramcote Hill. This rock, known locally as the "Hemlock" (or "Himlack") Stone—a term of uncertain derivation—presents a good instance of a distinct junction between the Lower and Middle Bunter sub-formations. The base is composed of red sand-rock, very distinctly laminated, and so much softer than the beds above that the action of the weather has given the rock the appearance of a rude gigantic column. These lower red beds extend about half way up the rock, and are distinctly unconformable to those above them.[*] They are capped by two or three beds of a hard calcareous breccia, which weathers with a remarkably mammillated surface—a character by which it is recognised as having furnished the material for many an ancient rude wall in the neighbourhood. The breccia is in its turn surmounted by the usual conglomerates, the varying hardness of which has given to the upper part of the rock a very rugged outline.

Mr. Hull says: "I commend the Himlack Stone[†] to the consideration of those who deny to the sea any share in sculpturing the features of our English landscape. That the Himlack Stone is an old sea stack seems to me perfectly clear. It is to the sea coast that we should point in order to find similar examples; and they are not uncommon among sandstones of Devonian or Carboniferous age on the raised terrace of the '25ft. beach' which fringes the Scottish coast." What part the sea may have played in the erosion of the Bunter rocks of the district it is, perhaps, impossible to say. That it played some part—for instance, during the Drift period—we shall see further on. Looking, however to the structure of the rock in question, no one who has examined it would doubt, I think, that the sea would make very short work of it as it now stands, appearing almost ready to topple over—a fate probably reserved for it at some future day, when the slow effect of weathering shall have eaten away somewhat more of the soft rock which forms its base. The hypothesis of quarrying has been resorted to; but though work of this kind has evidently been carried on at some time or other in the adjacent rocks, it would require a great stretch of imagination for anyone who had carefully examined the Himlack Stone to come to the conclusion that it was the result of such operations. My own belief is that its existence is due to the variation, laterally, of the lithological character of the Conglomeratic-series of the Bunter, and that the erosion of these beds (begun, perhaps, as Mr. Hull conjectures, by the action of the sea), has been continued through long ages, by sub-aërial agencies till the valley has been reduced to its present form. Stapleford Hill, which is contiguous to the Himlack Stone, has been worked, in years gone by, for copper ore. The Lower Bunter may be traced westward in the "soft, bright-red, striped sandstone of the village of Dale," where it is not more than 25 feet thick. Beyond this, according to Mr. Hull, it is lost sight of across a belt more that 30 miles in width, which stretches from the Peak District towards Charnwood; but it re-appears in North Staffordshire. That across that district the Lower Mottled Sandstone is wanting, is shown by the position of the Conglomeratic-series, which at Ashbourne, Alton, Derby, and other places are seen resting immediately upon Palæozoic rocks.* Near Nottingham the Lower Bunter rests upon the Coal Measures, the Permian rocks thinning out before reaching so far south. This has recently received additional proof from the sinking of the shaft at Wilford and the "boring" for coal at Highfield.

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[*] From a further inspection of this rock, I am inclined to think that the apparent unconformability here is the result of the weathering-out of the Lower Bunter Sandstone, *obliquely laminated* on a rather large scale.

[†] Professor Hull states that the word *himlack* is of Celtic origin: others have suggested a corruption of the word *cromlech*; but we do not speak of cromlech-stones. A friend of the author's has suggested the possible connection of the word with *axt-stein*, a name for similar rocks in Switzerland and South Germany. Thus, *Himlack Stone = Himmel-axt-stein*?

This sub-formation may be examined in the escarpments which appear between the Leen and Highfield, at Lenton. In spite of oblique lamination, the horizontality of the beds can be seen from the marl partings which occur at intervals. These necessitate the working of the rock in horizontal floors, in order to separate the marl from the fine red sand which has been dug here for many years to supply moulding material for the iron-works of Derbyshire.

PEBBLE-BEDS AND CONGLOMERATES.—These form a series of sandstones (harder than the last) through which rounded and subangular pebbles of quartzite are scattered, and often collected into compact beds of consolidated shingle. Angular fragments of slate and grit are also common in the rock. In some places the layers are so loosely composed that the pebbles may be pushed out with a common walking-stick; in others they form a true conglomerate. The pebbles, which are embedded in a scattered manner in the more consolidated sandstones, are often held so firmly as to break under the blow of the hammer rather than be loosened from their sockets. Oblique lamination is seen at every turn, and it is no uncommon thing to meet with bands of sandstone, of a deep blood-red colour, often assuming a lenticular shape, interbedded with those of a whitish or a light yellow colour. Good instances of such bands may be seen in the excavations for catacombs in the Church Cemetery, and in the play-ground of the Nottingham High School; also in many of the numerous cellars in the town. These red bands are generally harder, and more distinctly laminated than the beds among which they occur, and the division planes are often thickly coated with micaceous spangles.

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* Hull, "Permian and Triassic Rocks of the Midland Counties."

Ferric oxide forms the chief cement of the grains of sand which are themselves nothing but pure silica. By boiling even the reddest specimens of the sand of this formation in strong hydrochloric acid, and washing with water, I have obtained beautiful pure white sand.

The pebbles of this subdivision vary in size from six inches or more in diameter to less than a pea. They are of various materials: white, liver-coloured, green, grey, quartzite; grits; green and black slate, often marked with quartz veins; jaspers; gneiss, and even sub-angular blocks of sandstone of a different formation, are to be found; also rounded fragments of greenstone and felstone. No one can live long, I believe, in this neighbourhood, and make use of his eyes, without the idea occurring to him that the Bunter pebble-beds are consolidated shingle beaches, in which the pebbles were mingled with a good deal of loose sand. The question naturally arises: whence came the pebbles? We can identify only a small proportion with rocks such as are found at Charnwood. Then the great extent of these beds, from the Humber to Worcester, and westward to Cheshire and Shrewsbury, with an observed thinning-out of the whole in a S.E. direction, points to a northerly source. Mr. Hull believes that they were mainly furnished by the disintegration of the Old Red Sandstone conglomerates of Scotland, which once had a much greater extension in the direction of the German Ocean than at present. That these beds are a littoral deposit can scarcely be doubted, but from the great preponderance of sand over shingle, I imagine that the shores along or near which these deposits were formed, must have been, to some extent, protected; perhaps bordering some straits of no very great width. We know how in such cases shifting sands are formed by the tides and currents; as, *e.g.*, the Goodwin and Margate Sands. Now with the Pennine range occupying a position intermediate between the old land of North Wales, and the Palæozoic land before referred to in the direction of the North Sea, and those regions connected by the "barrier" across by Charnwood, the conditions at present existing about the straits of Dover might be approximately represented; and the general prevalence of false-bedding in the rocks in question is just what might be expected in a somewhat confined channel, the scene of the meeting and intermingling of tidal and river currents. On the other hand, the Chesil Bank, near Portland, shows how free shingle is from sand, when silted up by the breakers of a sea open to the ocean.

The general resemblance of the pebbles found in the Middle Bunter series to those of the Chesil Bank, and which can be traced only to the Old Red conglomerates of South Devon, is so far confirmatory of Mr. Hull's view of the conglomerates of the New Red being the "daughters" of the Old Red conglomerate of Scotland. I have looked frequently and carefully for indications of ice-action on the surface of these pebbles, but hitherto in vain. Very faint striations are discernible occasionally, but so faint, when compared with what one sees on the boulders of the Till, as to forbid any one but the advocate of a theory to infer their transport by glaciers. A common occurrence in the Bunter sandstones is that of masses of red or dark purple marl, known to the quarry-men as "fuller's earth." It is found generally in rolled masses and cakes, as if transported from the neighbouring Permian marls, which it resembles in character. Sometimes it is found restratified in very thin laminæ between the sandstone strata, more after the fashion of a film left by a river-flood than by the surface-action of the sea. Any portion of the Permian strata which might have been elevated above the sea-level, during some of the minor movements (of which there appears to have been many during what I have ventured to name the Poikilitic period), would of course be subject to denudation by fresh water; and fragments of marl thus brought down into the shallow Triassic sea, would get buried in the offing among the sand and the shingle. These lumps and cakes of clay might have come, however, equally well from the Upper Coal Measures; so that their derivation from Permian strata is by no means certain.

UPPER MOTTLED SANDSTONE.—This sub-formation is not developed to any great extent in the Nottingham and Derby area. Still there appears to be sufficient evidence to justify us in believing that the conditions under which the Upper Bunter sands were deposited (and which were, roughly speaking, a repetition of Lower Bunter conditions), prevailed to some extent in this area. In the village of Stapleford, a recent excavation has exposed a section, in which the Keuper marls are seen resting upon the eroded surface of some very soft, bright yellow, distinctly laminated sandstone, quite free from pebbles. I communicated with Professor Hull, and forwarded him a description of this section, in order to solicit his opinion upon it, and was happy to find that that gentleman concurred with me in thinking that the Stapleford rock must be a fragmentary portion of the Upper Bunter series, and that this series was once, in all probability, more largely developed in our area, but removed for the most part by denudation, before the deposition of the Keuper strata. One thing particularly noticeable in this section is the absence of any calcareous conglomerate or marly breccia, which, as I shall have to describe a little farther on, mark the junction of the Bunter and Keuper in several places in the immediate neighbourhood of Nottingham.

No formation contributes more to determine the physical features of the southern portion of the county of Nottinghamshire than the Bunter. Abutting upon the Valley of the Trent, on the south, it extends north in a broad band of poor country, until it disappears under the alluvial plain of the Humber. Much of this region was occupied in former times by Sherwood Forest; the glades and dales of "Merry Sherwood" being formed by the erosion of the softer portion of Bunter sandstone. To this day, though largely enclosed and brought under the plough, it goes by the name of the "Forest," even in places where not an ancient forest-tree remains; as *e. g.*, Bulwell Forest, Arnold Forest, and Papplewick Forest. Bestwood Park, the seat of the Duke of St. Albans, is situated on this formation, and further north the beautiful estates of Clumber and Clipstone, where it can still boast of many a fine tree. From its porosity, it contributes greatly to the water supply of Nottingham, lying as it does on the impervious marls of the Permian series, or the clays of the Coal Measures. Its porosity also gives it a dryness, which has marked the site of Nottingham, from time immemorial, as a fit one for human habitation. Here a troglodyte race found a rock, not only dry, but soft and easily hollowed, even with such rude tools as they possessed. Local antiquarians have laboured to refer some of these to the ancient British race. The earliest Saxon settlers found the rock already used in this way, as is evident from the name which they gave to it, *Snodena-gaham* (the home of caves). Not only is the rock beneath the town honeycombed by cellars and long passages, but the bold escarpment which faces south from Lenton to Sneinton, has undergone numerous excavations. At the latter place, some of these, called the Hermitage, are still faced with doors and windows, and inhabited; while in the other direction, the famous "Park-holes" bear traces of a primitive kind of sculpture. Dearing, a local historian of more than a century ago, tells of the discovery, in his time, of similar traces of work in subterranean passages beneath the town. Nottingham Castle, replaced, after its dismantlement by the "Roundheads," by a modern mansion, stood on the loftiest part of the bold southern escarpment. The facilities which the rock afforded for excavation, account for the extensive dungeons beneath the castle; one of which is said to have been honoured by the presence of David, King of Scotland, who was taken prisoner by Queen Phillipa, at Neville Cross, in 1346; and everyone knows how her husband, in the early part of his reign, gained access by a secret passage into the castle, since known as "Mortimer's Hole;" and so put an end to what was at once a gross scandal and a gigantic assumption of power. This passage is now filled with *débris* for about two-thirds of the way from the bottom; in the upper part, traces are still seen of the steps formerly cut in the rock. The weathering of a rock so distinctly jointed as the Castle Rock is, has, in the course of ages, given it a somewhat striking appearance. The Church Cemetery, before mentioned, is one of the most interesting spots of its kind to be found anywhere, on account of its caverns. For building purposes the Bunter sandstone is useless; but for water supply it is admirable, having all the powers of absorption of an enormous sponge.* In many parts the surface soil is no doubt formed by the disintegration of the rock, and the intermixture of vegetable remains; since in sections frequently exposed for building in Nottingham, a gradual transition is noticed from the sandstone to the mould. In other places, however, there appears to be a sharp line of demarcation between them, the laminated sandstone disappearing all at once; and in instances of this kind which I have observed, the materials above the line present more the appearance of drift, and contain many more large pebbles.

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* The effect of this upon the surface-soil may be easily seen, on comparing the dry ground on the east of the Leen, with the wet ground on the west, where it lies upon the Permian marl.

The varying degrees of hardness, and the unequal distribution of the conglomerate beds, have led to extensive sub-aërial denudation in many places, and the consequent formation of escarpments. Instances of this may be seen in the Park Terrace, Nottingham, in the "Nottingham Forest," overlooking the racecourse, and at Bulwell Forest. The most striking instances, for scenic effect, are those on the opposite sides of the Erewash: Bramcote Hill on the east, and Sandiacre Cloud on the west. The northern face of the latter is deeply weather-worn; and the unequal hardness of the beds has given the escarpment, in the long lapse of ages, a very rugged outline. The great east and west fault before mentioned, which runs along the north side of Stapleford Hill, brings the Millstone Grit into juxtaposition with the Bunter conglomerates, near the village of Stanton-by-Dale. A little further on towards that village occurs a sand-hole in the Bunter formation, where the fault has been reached, and the Coal Measure clays are seen lying against the Bunter conglomerates. The scenery about here is more striking than any in South Notts, with the exception, perhaps, of that about Bramcote. Between this village and Beeston, the ground, though high, between the two east and west faults, is not very uneven, on account of the horizontal position of the Bunter strata. To inhabitants of Nottingham and visitors to the town, the Castle Rock is undoubtedly the most salient geological feature. For some time I was myself, in common with other observers, somewhat puzzled by the presence of this promontory, like another Acrocorinthus, raising its huge front over the Valley of the Trent. It was easy to see that it is but a portion of the Middle Bunter sub-formation, which extends from about the western limits of the Park to Sneinton. The question was—Why should this project as it does, while the strata on each side of it were hollowed out so as to form Park Valley on the one side, and that which lies between it and St. Mary's Church on the other? This may perhaps be accounted for by taking into account the *jointage* of the rock, which recent access to it, all along its base, has enabled one to examine a little more minutely. The rock is in fact intersected by a series of "master-joints," which have a general parallelism to one another, and run in a north-westerly direction through the rock from its southern face. Some of these may be observed intersecting the rock, in a cutting on the north side of the Castle, between it and Standard Hill, the same direction being there maintained: even in the Lower Bunter at Lenton the direction of the joints is the same. Taking into account, therefore, the direction of these joints, and the great horizontal variation in hardness of the whole Middle Bunter series, the causes which determined the position and direction of the two valleys just mentioned, and the consequent projection of the Castle Rock, are perhaps made out: the joints have served as lines of weakness, along which denudation was facilitated.

THE KEUPER.

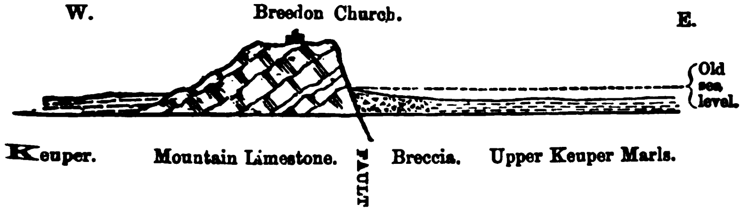
Walking through the town and suburbs of Nottingham, from west to east, we pass from one formation to another; each a member of the Trias. The ancient borough stood entirely on the Bunter; the Castle surmounting one part of its southern face, the noble pile of St. Mary's Church the other. In the great extension of the town that has occurred of late years, Nottingham has spread far beyond its ancient boundaries, and now overlaps (if one may be allowed such an application of the term) the Keuper outcrop. The correlation of the English Triassic rocks with those of Germany, showing the absence of an intermediate formation, would lead us to expect to find evidences of a break in time, in the unconformability of the two series here brought into juxtaposition, and in the erosion of the Bunter which constitutes the lower series. Perhaps not during the whole, but very probably during some portion of the time occupied by the deposition of the Muschelkalk, our area was above water, and consequently subject to degrading influences. Whatever may have been the thickness of the Upper Bunter here, it had been, as we have seen, generally worn away before the Keuperian age. The Dolomitic Conglomerate which lies at the base of the Keuper beds, in the South Wales District, is also wanting here; so that this formation is represented about Nottingham by only two divisions, as follows:

Keeper {
2. Red and Variegated Marls and Upper Keuper Sandstone with Gypsum.
1. Lower Keuper Sandstone and Marl ("Waterstones").

A glance at the Survey map of the district will show that this formation occupies a larger surface-area in the Nottingham district than any other. With the exception of the southern escarpment of Bunter sandstone, described in a previous portion of this paper, the whole of the Valley of the Trent, for many miles below Trent station, is an elongated hollow, scooped out of the Keuper strata. In some places—as at Clifton, Ratcliffe-on-Trent, and East Bridgford—the red marl forms steep, almost perpendicular cliffs, overhanging the river; and the hills which enclose the valley on that side are formed of the upper series of marls. Above the confluence of the Soar with the Trent, in the neighbourhood of Castle Donnington, and even in that town itself, the Lower Keuper beds are seen resting upon shales and grits, which Professor Hull considers to be of the Millstone Grit series. From the cliffs which there overlook the river-valley, the Keuper stretches away to the south, till it abuts against the old land of Charnwood. At Breedon there are several inliers of the Mountain Limestone, which must have formed islands in the Triassic sea. They are at the present time quarried for lime-burning. The strata have a westerly dip of about 45°. The eastern face of the hill, which is surmounted by Breedon Church, is an almost perpendicular precipice, and must have been thrown up by a fault in pre-Keuperian times. That it formed a precipitous cliff on the east, in Keuper times, is proved by the quantity of angular fragments of the limestone, to be found embedded in the red marl, that now abuts against its flank. These resemble precisely the *débris* which now lies on the surface at the foot of the cliff, the result of the disintegrating influences of rain and frost. When such fragments fell into the waters of a lake or inland sea, they, along with the marly deposit, accumulated against the cliff at its base; and are found now, where they were originally deposited, unaltered, except so far as to have taken a surface-colouring from the ferric oxide of the marl. They afford direct evidence of the absence of tidal or surf action during their accumulation, and point to the existence of inland waters during Triassic times. The facts will be readily understood by a diagram.

Fig. 4.

SECTION ACROSS BREEDON HILL.



All along the south-eastern side of the Trent, from the confluence of the Soar, the hills, on account of their marly nature, are rounded off into gentle slopes. At some distance from the Trent they are capped by Lower Lias, indications of whose former extension in the direction of the Trent are seen in the outliers of that formation near Gotham, a village of some notoriety. On the north side of the Trent Valley the high grounds known as the "Plains," and stretching away in the direction of Woodborough and Southwell, form the upper surface of the Keuper series.

It would be an interesting task, if practicable, to trace the *junction* of these beds with the Bunter, over a considerable track of country in Nottinghamshire, but the exposures of it are few and far between. There are, however, several close to Nottingham :

(1.) In Red Lane, which leads up from the Mansfield Road, to the Woodborough Road, the junction is exposed for a short distance. A thin band of calcareous conglomerate occurs here, forming a sharp ledge in the roadside at the top of the pebble-beds. It contains both rounded pebbles and angular fragments, some of considerable size. There is, perhaps, a slight unconformability here between the Bunter and the Keuper. By ascending the hill in the lane, and continuing one's course up to the Mapperley Plains, nearly the whole of the Keuper series may at the present time be examined with great facility.

(2.) The calcareous conglomerate has been observed by Mr. E. Wilson, F.G.S., in some excavations, now covered up, on the east side of the town. He states that it contained "an assemblage of red, white, and black pebbles of quartzite, firmly bound together in a compact calcareous cement: the pebbles resemble those of the Bunter, from the denudation of which they were probably derived."

(3.) On the hill-side east of Sneinton adjoining Rough-hill Wood, the junction may be observed, marked by a number of small rounded pebbles embedded in red marl.

(4.) Quite recently, Mr. Wilson was good enough to direct my attention to a new road in process of cutting through Blue-bell Hill from Great Alfred Street. In a culvert sunk below this road, a most interesting section was obtained, showing not only the junction of the two formations, but the great preponderance of sandstone at the base of the Keuper at this spot. I measured the strata, and obtained the following series:

	ft.	in.
13. Red marl	5	0
12. Sandstone with marl partings	2	0
11. Ribbon-band of marl, with interbedded material from the Bunter (on an average)	1	0
10. Sandstone band, more compact and homogeneous than 12	2	0
9. Red marl	9	0
8. Keuper sandstone	5	0
7. *Yellow limestone*	0	2
6. Keuper sandstone	0	9
5. *Yellow limestone*	0	3
4. Keuper sandstone	1	6
3. *Yellow limestone*	0	3
2. Hard red conglomerate	1	0
1. Bunter pebble-beds	2	0
	29	11

Here, within a vertical distance of 30 feet, we have a considerable variety. The most interesting circumstance is, perhaps, the presence of three distinct beds of a yellow ochreous-looking limestone, homotaxial, probably, with some portion of the Muschelkalk of Germany, and possibly synchronous with it too.

LOWER KEUPER ("WATERSTONES").—These beds are exposed in many places on the east and north-east of Nottingham. Good sections may be observed in Windmill Lane at Sneinton, and by the side of the railway at Colwich; but by far the best, because the freshest, sections at present are those formed by the cuttings in the new railway near Gedling and the Woodborough Road.

The deepest shaft sunk for the tunnel which is to pass beneath the 'Mapperley Plains' is 180 feet. To this may be added some 20 feet, or perhaps a little more, to make up the total thickness of the Keuper series. No beds of gypsum have been passed through, and, so far as I am aware, this mineral is absent from the Lower Keuper about Nottingham. The sandstones brought up from the tunnel have a very distinct and well-marked "grain." The bedding surfaces of these sandstones are frequently ripple-marked, and occasionally bear traces of sun-cracks and rain-pittings. Marl partings are very common. Professor Hull states that footprints of *Cheirotherium* have been observed at Castle Donnington, but I have not heard of any being found in the immediate vicinity of Nottingham, until I was so fortunate last summer as to pick up a block of stone bearing the unmistakeable cast of the small fore-foot of one of these creatures. The slab had fallen out of the cliff that overhangs the Midland Railway at Colwich. The specimen is now in the museum of the High School.

The meaning of the term "waterstones," as applied to the sandstones of the Lower Keuper, is readily seen in the cuttings, before referred to, of the new railway. The outcrop of the strata allows the entrance of water: traversing the sandstones which lie nearly horizontally, and its passage in a transverse direction being prevented by the intervening layers of marl, it trickles out freely wherever the edges of the strata are exposed below the level of the outcrop. In this way numerous springs are formed. The result of this may be seen in the wet cuttings in the Keuper series, which present a striking contrast with the dry cuttings in the porous Bunter sandstone, along the same line of railway. There is one band of sandstone about five feet thick, which (varying in its homogeneity) appears to be pretty persistent in this area. It generally surmounts some 20 feet or more of marls, and may be observed in various places; *e.g.*, at Sneinton, St. Anne's Well Road, Woodborough Road, in the cuttings of the railway just referred to, and in the cutting at Red Hill on the Mansfield Road, about four miles north of Nottingham. In the section I have described at Blue-bell Hill, marls at this horizon give place to material of a more siliceous character.

UPPER KEUPER (RED AND VARIEGATED GYPSEOUS MARLS AND SANDSTONES).—According to Professor Hull the sandstones of this series are of unusual importance in the neighbourhood of Nottingham, from the thickness of the beds and the durability of the stone for building purposes. These beds do not appear to be confined to any particular horizon, but thicken in certain localities. The marls form a stiff soil at the surface, rendering agricultural operations somewhat difficult, if the soil is either too dry or too wet. They also furnish material for bricks, which is extensively worked at Carlton, Sneinton, Mapperley Plains, and other places near Nottingham. The last named are the largest of the works of the kind in the district; and so great is the supply of bricks from that place alone, that it has been said that "Nottingham once lay on Mapperley Plains." To the north-east of the town the outline of the marls is very irregular, on account of their erosion by atmospheric agencies. This has gone on to such an extent that the upper marls are frequently worn through, and the Lower Keuper series exposed ; in the valleys, for example, in which lie the villages of Carlton, Gedling, and Lambley. The Cocker Beck, which flows by Lambley, and the Dover Beck which passes through Epperstone, have eaten their way down into the Lower series; and the phenomenon is repeated by the Greet, near Southwell. At the bottom of the valleys thus formed, as for example at Lambley, are the curious "dumbles," a local term for a deep channel cut backward in the nearly horizontal strata, by the running water of a brook, so as to form a miniature cañon, the banks of which are generally overhung with trees and brushwood. At Lambley Dumble is found the so-called "petrified moss." The physical geography of the Keuper district is therefore interesting, though not remarkable for scenic effects in the landscape. On a small scale it illustrates very well the formation of plateaux by horizontal strata.

A notable characteristic of the Upper Red Marl series in our area is the abundance of calcium sulphate, and the entire absence of the chloride of the same metal, which attains the enormous thickness of 90 feet in the corresponding strata in the Cheshire area. It may be that, while the sea gained occasional access to the latter, the Nottingham area was shut off from all communication with it during the Keuper period. That the inland sea was salt, we know, however, from the frequent occurrence of *pseudomorphs* of rock-salt. These are common enough on the surfaces of the slabs of sandstone, that are interbedded with the marls in the uppermost parts of the series ; though not confined to that horizon. In the gypsum-quarries, at Newark, they may be picked up plentifully, and more sparingly at Carlton, Colwich, and at Blue-bell Hill. Those which I have seen are mostly from the grey-coloured marls, which seem to mark the incipient stages of those changes which ushered in Rhætic conditions. The conjecture that the gypsum may have been deposited "from submarine gaseous emanations, or from hot springs which have continued to flow in the same spot for ages,"* certainly seems to force itself upon one in examining it *in situ*. These deposits vary in thickness from that of a sheet of paper to nine feet—the thickness of the beds worked at Chellaston and Aston, places situated on an inlier of red marl which forms, in one sense, an island in the Trent alluvium, between Castle Donnington and Derby. Red Hill, near Thrumpton, shows traces of the gypsum-works of former years. This is now bored through by the tunnel opposite Trent Station; and in the recent widening of the cutting to lay down an extra line for the heavy traffic between Trent and Leicester numerous ribbon-like bands of satin-spar were exposed, the crystals being in some cases three inches long. The thicker beds are generally amorphous or saccharoidal, and commonly known as "alabaster." Some of these are of a pure white, others of a delicate flesh-colour. They lie sometimes in regular floors, and are then worked either by open quarrying or by driving a horizontal mine into the side of the hill. Beds of this description are now being worked at Newark; and quite recently a quarry has been opened at a horizon very little below the Rhætic Series, which here crops out on the brow of the hill. The gypsum, at this spot, occurs in every variety of form and condition: large round masses, as much as three and four feet in diameter, of the pure salt; lenticular masses of the same material, both white and pink; beds largely mixed with earthy impurities; and innumerable ribbon-like bands extending in all directions, quite irrespectively of the bedding-plane of the marl,—at one time cutting across the lamination at every possible angle, at another following the direction of that plane. Where the thick masses occur, the strata have been thrown into strange contortions, the flexures having an anticlinal curvature over the massive beds of gypsum; as if the blocks of the mineral, becoming hydrated, and so increasing both their bulk and their rigidity, had heaved up the semi-consolidated strata above them. The appearance of this section is the more interesting from the alternation of red and grey bands of marl which follow the outline of the concretionary masses. There is a peculiar character discernible in the thin gypseous veins, wherever I have observed them, both at Newark and nearer Nottingham: that is, the general *tendency of the crystals to assume a vertical position*, and one not necessarily at right angles to the surface of the vein. There was therefore some force acting upon the particles simultaneously with that which produced crystalization. What was that force? Researches in pyro-electricity would seem to suggest the connection of this phenomenon with terrestrial magnetism.

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* Lyell: "The Student's Elements of Geology," p. 354.

According to Mr. Sterry Hunt (Quart. Journ. Geol. Soc., Vol. xvi.), gypsum-deposits are of two classes:

(1.) Those formed by the direct action of sulphur-dioxide upon beds of limestone.

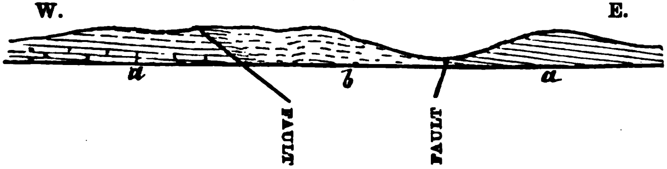
(2.) Contemporaneous beds of sulphate of lime, interstratified with marls, dolomites, and rock salt. The continued action of bi-carbonate of lime upon sodium or magnesium sulphate gives a saturated solution of $Ca\ SO^4$ (according to Williamson 1 part of the salt to 400 parts of water); and after this degree of saturation is reached, precipitation must of course ensue. This process is not interfered with (according to Mr. Hunt) by the presence of sodium chloride; so that, by continued additions of bi-carbonate of lime (which is formed daily wherever rain-water, charged with carbonic acid, acts upon limestone rock), the magnesium or sodium sulphate of sea-water may be converted into calcium sulphate or gypsum. The salt is generally found combined with two molecules of water of crystallisation. This is driven off at 130° C., but if the salt be not calcined in the process, it has the power of re-combining with water; and in this state it forms the valuable commercial commodity known as "plaster of Paris."

Before leaving this part of the subject it is desirable to notice a pair of faults which run from Colwich in a north westerly direction towards Mapperley. The throw of these two faults being in contrary directions they form a "trough." One of them intersects the face of the cliff, which overhangs the railways at Colwich; so that, in passing along the Great Northern Railway, a capital view is obtained of the Upper and Lower Keuper strata side by side. The throw of the fault which is visible (that to the left in Fig. 5) is equal at least to the height of the cliff, which is about 50 feet; the other fault is not directly perceptible, since it has formed a line of weakness upon which denuding forces have operated; but its existence is necessarily inferred from the re-appearance of the

Lower Keuper strata to the east of it. This will be understood from the accompanying diagram:

FAULTS IN KEUPER STRATA AT COLWICH, NEAR NOTTINGHAM.

FIG. 5.



b. Upper New Red Marls, with Satin-spar and Pseudomorphs of Rock-salt.
a. Lower Keuper Strata (Waterstones).

These faults are indicated on the Survey map, but the true position of that to the left has not, I think, been accurately laid down. By the surveyors, it is made to pass too near to Sneinton, from which I infer that the exposure of it in the cliff was not made at the time the survey of the district was done. On the other hand, the position of the Bunter rocks west and east of Sneinton (in the latter place they are seen in the hill-side underlying the Keuper), prevents us believing in the existence of a fault in the exact position indicated on the map. The more westerly of the two faults may be traced easily across the north-eastern suburbs of Nottingham, since it is exposed at the present time at Blue-bell Hill, in the Woodborough Road opposite Cranmer Quadrant, and in the grounds of Forest House opposite the Church Cemetery.

Though the traces of life in the Keuper are few, an advance is shown in this respect upon the Bunter series.

Footprints of reptilian creatures have been already referred to, and at Chellaston numerous foraminifera, figured and described by Professor T. Rupert Jones (Quart. Journ. Geol. Soc., Vol. xvi., p. 453), have been found in the gypseous marls. Fish-scales are found, too, as we ascend the series.

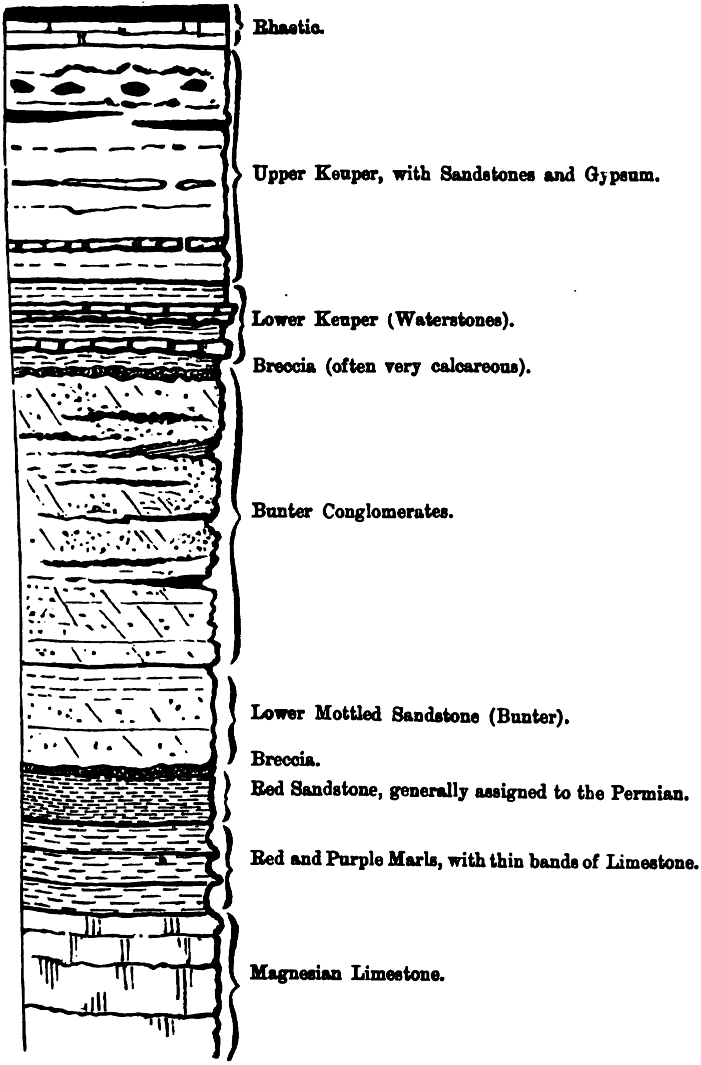
The theory propounded of late by Professor Ramsay, to account for the character of the red rocks of the Permian and Triassic series, is familiar to geologists. In Cheshire the concentration of salt water by evaporation has left its deposit in the beds of rock-salt which abound in that district: in the Nottingham area we find traces of this and something more. The data furnished to us are mainly the reptilian footprints and the frequent occurrence of pseudomorphs. Both these would result from the same set of physical conditions. Assuming the area to have been cut off from the ocean, then, in periods of drought, the saline waters of this area must have receded. This recession would leave the margins of the inland sea or lake exposed to the sun, and the footprints of the huge monsters which crossed the yet soft mud would become permanently impressed upon it as it became indurated by the heat of the sun. A subsequent influx of water would fill them up, and take a cast of the impressions by the sediment which it brought with it. The same cause which made the waters recede would also concentrate them by evaporation. Crystals of salt would thus be left upon the soft mud, which, on hardening, would retain their cubical impressions; and the crystals, being re-dissolved at a later period by an influx of waters, a cast of the impressions left by them would be taken by the sediment and preserved to us in the pseudomorphs. The physical conditions of this period were evidently unfavourable to the life of either mollusks or corals; one of these conditions being apparently the absence of carbonate of lime which is necessary to supply material for the calcareous exo-skeletons of the former, and the endo-skeletons of the latter. Soft-bodied creatures, however—first-cousins, many of them, to the toad—inhabited the adjoining land, and as they waddled across the shores, they verily left their "footprints on the sands of [Triassic] times."

In studying the Triassic rocks in this part of the world, one seems as if brought face to face with a blank—a sort of desert—and it is therefore refreshing to get beyond these geological wastes, and mount to the horizon where they pass into the Jurassic series, and a gradual influx of numerous forms of marine life is met with.

From a general review of the strata included in this paper in the Poikilitic Series, the first thing, perhaps, that strikes one is the cumulative evidence in favour of the views above referred to, as lately expressed by the Director-General of the Survey, relative to the conditions under which the red and variegated strata were deposited; and the power of accurate generalization displayed by him is forced upon one on applying his theory, and finding it fully verified, in a particular district.

On the other hand, a conviction is arrived at that, while the whole period marked, in the district under review, by the deposits that occur between the Coal Measures and the Jurassic series, was one of *unrest;* yet we look in vain for any great or marked dislocations in the order of the strata. If any approach to this is to be recognized, it is at the horizon which marks the junction of the Bunter and Keuper formations, where perhaps, even in England, the Muschelkalk is not entirely unrepresented. The following may be taken as a typical section, in vertical order, of the Poikilitic strata of the district:

FIG. 6.


Rhaetic.
Upper Keuper, with Sandstones and Gypsum.
Lower Keuper (Waterstones).
Breccia (often very calcareous).
Bunter Conglomerates.
Lower Mottled Sandstone (Bunter).
Breccia.
Red Sandstone, generally assigned to the Permian.
Red and Purple Marls, with thin bands of Limestone.
Magnesian Limestone.

If now we trace out the physical history of the geological age comprised between these limits, we find indications of frequent oscillations in the level of the land and of the sea-bed, relatively to the sea-level.

The Magnesian Limestone speaks to us of a deep and clear sea where the dolomite was formed, free from any great admixture of earthy sediment. By degrees the bed of the sea rose, and came within reach of currents which had the power of transporting fine mud, but not the coarser ingredients, of sedimentary masses ; and thus the red and purple marls were formed. The formation of these was, however, intermittent, so as to allow time for the formation of thin bands of dolomite at intervals. Then followed a time when the bed of the sea had so far risen as to be the receptacle of the sandy sediment which constitutes the material of the Upper Permian sandstones. For a time the shore-line must have shifted across this area, and along this shifting line the materials, drifted from a greater or lesser distance, were deposited to form the Cinder-hill and Kimberley breccias. Much of this, however, must have accumulated from the degradation of the adjacent land.

The order of motion was now reversed for a space, and the deposition of the sands of the Lower Bunter took place. The false-bedding prevalent in this, and the sub-formation next above it, has been already pointed out. The currents during the deposition of the pebble beds and conglomerates must have been very much intensified in their force and restricted as to the area within which they acted. A subsequent upheaval probably exposed these recently-formed beds to denuding agencies, and thus they supplied the materials of the conglomerates which, as we have seen, frequently form the basement of the Keuper series. Then followed a slow and gradual submergence, during which the beds of sandstone of the Lower Keuper were deposited ; a submergence, however, which would seem, from the frequent alternation of sandstone and marl, to have been not continuous, but intermittent.

Finally, in the still, though not on that account necessarily very deep, waters of the *inland* salt sea, the deep-red marls were formed, until at length the barrier which shut off the area from the ocean was removed or submerged, and the state of things which marks Liassic times began. The passage from the one period to the other, marked by the Rhætic or Penarth Beds, would seem to have begun even earlier. Reference has been already made to the fish-remains occasionally met with in the uppermost Keuper strata. In the museum of the Nottingham High School is a grey slab from that horizon, which was picked up by one of the pupils in a gypsum-quarry at Newark, and on its surface the pseudomorphs are interspersed with scales of *Gyrolepis*. Here we seem to have a precursor of the Rhætic "Bone-bed;" and a few more examples of this kind would lead us to refer the grey and greenish bands of the Upper Keuper to occasional inroads of oceanic waters.

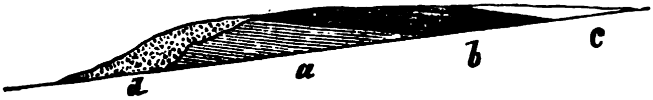
RHÆTIC BEDS.

The persistency of these beds across England has been now pretty well made out, by the description from time to time of different portions of them. About seven years ago, Mr. Burton of Gainsborough described, in a paper read before the Geological Society, some beds of this series, which occur near that town, and had then been brought to light through the lowering of the gradients of the Great Northern Railway. About the same time, the Rev. P. B. Brodie described some outliers of these beds in Warwickshire. I believe, however, that until quite recently no sections had been described between these two places. Some time ago Mr. Etheridge, of the Museum of Practical Geology, being in the neighbourhood, detected Rhætic strata as he passed them in the train at Elton, on the Great Northern line, the bank having been recently cut back to enlarge the station premises. The same gentleman also discovered them in the cutting of a new branch line near Leicester, and near Barrow-on-Soar. Encouraged by these facts, I prosecuted the search along the line of strike of the Lias, and was so fortunate, in the spring of 1873, as to come upon some gypsum quarries at Newark, where a fine section of Rhætic beds is exposed. Two of the three zones, into which the series is generally divided, are well represented; and the passage from the red marls below is well shown. Above the gypsum beds described in the last section of this paper, we see grey and greenish lines of marl intervening between the red strata; the former gradually thickening and the latter thinning, as we ascend the face of the rock in the quarry, until finally the red bands disappear, and we get a continuous stratum of the hard greenish marls, weathering and splitting in a cuboidal manner, and constituting, according to some authors, the lowermost member of the Rhætic group. The line of demarcation between these and the black "Paper-shales," which rest upon them, is very distinct: here and there a thin calcareous band occurs, but I have not succeeded in finding the "Bone-bed." These thinly laminated shales have their surfaces extensively coated with ferric oxide. One band of them, only a few inches thick, yields *Pullastra arenicola* and *Avicula contorta* in abundance, and I have no doubt that the shales would amply repay a thorough examination from top to bottom, if one could find the necessary time. Here then we have the following section:—*

	Feet.
2. Black Paper-shales, abounding along a certain band in *Avicula contorta and Pullastra arenicola*	10
1. Grey and greenish marls	15
	25

The "White Lias" is not seen *in situ*, but fragments of a similar stone are found in the surface soil above, and are exposed by the frequent subsidences that have ensued upon the removal of the gypseous strata beneath. The cutting of the road from Newark to Leadenham passes through the shales, where they lie on the eroded surface of the green marls, overlooking the Trent Valley, so that they are exposed in the road-side.

FIG. 7.



d. Rubbly mass of disturbed Paper-shales, much broken, mingled with fragments of Lias limestone and Bunter pebbles.
c. Lower Lias.
b. Black Paper-shales.
a. Greenish and grey marls

The materials marked *d* are evidently derived from the shales at *b*, and appear to have been carried into their present position by some abrading force such as an ice-floe might exert, while another force brought the Bunter pebbles to the spot. Here we have, then, a "boulder-clay" on a small scale.

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* Since the publication of an abstract of this paper in the Geological Magazine for July last, Mr. Horace B. Woodward, of the Geological Survey, has written to state that he and his colleague discovered the Rhætic Series here about the same time with myself. He also states that, on having an old lime-pit in the Lias deepened, he found the uppermost zone of the series *in situ*. He gives the total thickness here as about 50 feet.—*Geol. Mag.*, *Oct.* 1, 1874.

Mr. Teall, B.A., F.G.S., of St. John's College, Cambridge, when lecturing for the University in Nottingham, Leicester, and Derby, in the early part of this year, noted another section of the Rhætic Series at Spinney Hill, near Leicester. This was exposed by the extension of some brick yards. The following statement was furnished me by Mr. Teall:—

SECTION OF RHÆTIC BEDS NEAR LEICESTER.

	Feet.
3. Black Paper-shales	4 to 6
2. Soft green marls...	20
1. Red and greenish marls to the base of the quarry......	

The transition from the Keuper to the Rhætic is marked here also by the usual alternation of green and red bands. I am informed by Mr. Teall that Mr. Harrison, of Leicester, has found in these shales *Pecten Valoniensis*, *Cardium Rhœticum*, *Avicula contorta*, and *Pullastra arenicola*; and has added to the known fauna of these beds *a species of star-fish*.

It is interesting to correlate the above instances with others previously described to the south and north of them; and thus to observe the remarkable persistence, in the English area, of beds, which, though limited in dimensions here, play a most important part in continental geology.

THE LIAS.

This formation plays but a subordinate part in the geology of the country about Nottingham, until we get into Leicestershire and the Vale of Belvoir. It caps the hills which enclose the Valley of the Trent on the south side; where, from East Leake and Bunny, on the west, it stretches away to the north-east into Lincolnshire. It extends up the east side of the Soar to the well-known lime-pits of Barrow, which have yielded a rich harvest of fish and amphibian remains. By a gentle south-easterly dip, these strata pass beneath the Marlstone of the Middle Lias. A great part of the Vale of Belvoir is a dip-slope on the surface of the Lower Lias strata. The drainage of this area is generally to the north-east into the Trent; most of the streams rising at the foot of the Marlstone escarpment, which, bold and richly wooded, faces to the north-west, and is surmounted by the lofty towers of Belvoir Castle, that command a view of the valley for many a mile. The

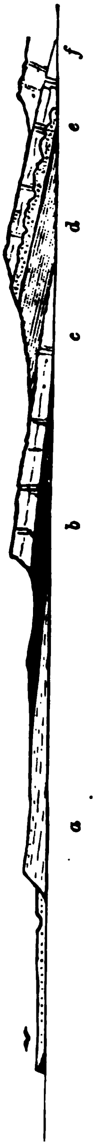

Fig. 8.

γ. Alluvium of the Trent Valley.
f. Inferior Oolite (Lincolnshire Limestone).
e. Upper Lias Sands (ferruginous).
d. Upper Lias Blue Clays.
c. Marlstone (Middle Lias).
b. Lower Lias Limestone and Shales.
a. New Red Marl (Keuper).

Marlstone forms a range of hills which stretches away into Lincolnshire, and is penetrated by the railway from Nottingham to Grantham. The Marlstone, from its porosity, and the jointed and broken condition of its strata in many places, resting as it does upon a basement of clay and shales, serves a purpose very similar to that of the Bunter—as a reservoir for water; the brooks of the district, therefore, generally spring from its base.

The Marlstone would no doubt very well repay working to one who could command the requisite leisure. In the one or two sections I have seen near Belvoir Castle, hard calcareous layers occur; and these abound in *Rhynconella tetrahedra* and *Terebratula punctata.* Belemnites and ammonites, both in a fragmentary state, are also frequently met with.

The dark blue clays of the Upper Lias have been recently exposed in the cutting south of Grantham station. Here *Leda ovum*, *Myacites decurtata*, *Ammonites bifrons*, *Ammonites serpentinus*, and numerous guards of belemnites were picked up. Selenite, too, is very abundant; some of the rhomboidal crystals being very large and perfect, though it frequently also occurs in long plates. The clay is extensively worked for bricks in the neighbourhood of Grantham.

The relation of the strata in this direction will be readily seen from the accompanying diagram,(Fig. 8) which represents a section drawn along the Great Northern Railway from Nottingham to Little Ponton beyond Grantham.

DRIFT AND ALLUVIUM.

The "Drift" may be seen in numerous places, scattered over the south of Nottinghamshire. Those places where I have observed it are, however, generally upon the Bunter formation. Its immediate contact with these rocks, and the similarity of its contained pebbles to those of the Bunter, together with the quantity of sand of the same nature as that of the rock beneath—which has been stirred up and mingled with the pebbles so as to form often a rude, incipient bedding—point to a time when this drift was scattered over a wide area of shallow waters, which most probably occupied a great part of the present Trent basin in the Northern Drift period. This we might expect on *à priori* grounds, since the rocks of the Bunter country would suffer denudation faster than the more distinctly stratified marls of the Keuper; guarded too as these are by the more compact beds of sandstone. Consequently I conceive that the patches of Drift—such as one now sees upon the *higher* parts of the Bunter country, as, *e. g.*, above Lenton, between Beeston and Bramcote, at Annesley, at Cinderhill above the railway-cutting, at New Basford, and frequently about the high ground in Nottingham itself—are but the remains of what was once much more widely distributed; and that much of this has been removed subsequently and carried down into the Trent Valley, where the extensive low-level gravels, such as are found at Beeston and Sawley, testify to the vast power of running water that has been exerted in this district in Post-Pliocene times. Further proof of the erosive action of running water is found on examination of the valley of the Leen. This stream rises in a low ridge known as Robin Hood Hills, to the south of Mansfield. At the present time, its course is due south, until it emerges upon the valley of the Trent; and (before its present artificial channel was constructed for it by the monks of Lenton Priory, along the foot of the Castle Rock) it flowed across the alluvial plain into the Trent, converting the meadows, on a large portion of the estate of that fraternity, into useless and unhealthy swamps. The valley of this river seems to have attracted both Saxon and Danish settlers in early historic times, of which we find traces in the Norse suffix of the name Lin-*by*, and the Teutonic suffix of the name Len-*ton*. The upper portion of the valley through which this stream flows, for the greater portion of its course, appears at first sight to have been originally a bay, scooped out of the soft Bunter rocks, since it is surrounded by these on the east, north, and west, with an opening only to the south. The Skegby Hills shut it off from the Erewash Valley. That this is the result, however, not of marine, but of fluviatile action, will appear from several considerations:—

(1.) We find several outliers of Bunter, such as the one mentioned above, at Cinderhill; and this one has only been severed from the main mass of the Bunter formation by the Leen Valley, which at Bulwell and Basford becomes narrowed, while the stream flows at the former place over Permian marl, at the latter over the Lower Bunter. Had the upper part of the Leen Valley been already formed by marine agency, it may fairly be assumed that the river would have flowed round the western side of these outliers, and not have severed them from the rocks of the same formation lying to the east.

(2.) On walking over the country in the upper part of the Leen Valley, where the sub-soil is Permian, and the soil itself often nothing but Permian marl, one finds Bunter pebbles so thickly strewn upon the surface as to cause great inconvenience to the farmer, who is glad to have them removed from his fields for road-mending. While, therefore, the slow erosive action of rain and running water has removed the sandy matrix in which these pebbles and small " boulders " were once embedded, it has not been able to remove them far from the positions in which they were deposited in Bunter times; except to allow them to subside to a lower level, until the process of denudation was arrested by the more tenacious Permian strata, which stretch across all the upper portion of the Leen Valley, and upon which the pebbles and " boulders " now lie.

For the above reasons, I believe that the result of the latest marine action upon the country occupied by the part of the Trent Basin east of the Pennines, was to *plane off* in a rough manner the surface of the land; and that the *deeper features* which exist at present—including the Erewash and Leen valleys, and even the Trent Valley itself for a great part of its course—have resulted from the subsequent action of sub-aërial agencies. And in this, it will be remembered, I have but attempted to follow, by parity of reasoning, the argument by which one of the foremost of living physical geologists has explained the structure of the Weald.* Among the minor features of the landscape which date their commencement from such a time, would come probably the Hemlock Stone, and the hills adjoining it, with their pebbly caps. The Castle Rock too, must, I think, have then *begun* to stand out in relief; and it is within the range of rational conjecture that a stream from the north (perhaps draining the present area, at a higher level, of the Leen itself), may have flowed down what is now Park Valley, into the Trent. However that may be, the Castle Rock, with its hard conglomeratic beds, would prove a formidable obstacle to the north-easterly flow of the Trent waters, when the chiselling down into the Keuper strata had once commenced; and this would sufficiently account for the eastward deflection of the present Trent Valley from its general north-easterly course, which is to be seen at the present day.

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* Ramsay's " Physical Geology and Geography of Great Britain." Ch. viii.

There is much obscurity about the the time when the waters of the Trent basin began to converge towards their present main artery, and to form, according to Prof. Ramsay, a tributary, or tributaries of the Rhine. According to recent speculations by the same gentleman, we must not go farther back than Miocene times for this. So that between that period and the deposition of the Trent alluvium, we must place the gradual recession of (1) the Chalk escarpment, which now forms the western face of the Lincolnshire Wolds; (2) the Oolite and Lias escarpments, which are now parallel with the valley on its eastern side; and (3) the erosion of the marly strata of the Upper Trias, through which the Trent now flows. The Trent basin, formerly at a higher level, probably had *several* outlets to the east; and two of these have been widened and deepened, contemporaneously with the sculpturing of the features of the basin itself, so as to form the present passages through the Oolite escarpment, which are occupied, the one by the Humber, and the other by the Witham at Lincoln.

The recent age of THE ALLUVIAL DEPOSITS OF THE TRENT is shown by the discovery of bones of recent Mammalia in several excavations near Nottingham. At Wilford, in sinking the shaft for the coal-pit, they were found lying at the bottom of the alluvium, 25 feet from the present surface of the ground. It is, perhaps, to those pre-historic times, when mighty floods spread across the valley and deposited the present low-level gravels—before, too, the river had cut its present channel into the Alluvial Deposits—that we must refer the construction, by a troglodyte race, of the cave-dwellings which penetrate the whole southern face of the rock that overlooks the valley at Nottingham. So striking a feature did these present to the earliest English settlers, that, as we have seen, they named the town from them. A little later, the Vikings made the Trent (the "Humber," they called it) their highway into the heart of the country, where they established a confederacy of commonwealths—the "Five Burghs," of which three were in the Trent Basin. In their stronghold upon the Nottingham Rock, they made a successful stand against the most powerful of the Saxon kings (Edward the Elder); and their predominance here for several centuries has scarcely yet lost its influence upon the linguistic and other characteristics of the population. Forming, as it did, for a long time, the frontier of the ancient kingdom of Northumbria, the Trent must have acquired in early times, political importance; and to this day, as Mr. Carlyle has reminded us, the successors of the primeval Trent bargemen (believers in Odin and Aegir) preserve to us a fragment of the old mythology in the name they give to a peculiar dangerous swell to which the river is subject; the word "Eager" still surviving "like the peak of a submerged world."

At the close of a review, however imperfect, of a district, in its natural aspect, one can scarcely refrain from taking a glance at its human, and consequently the most intensely interesting, associations. Around the ancient borough of Nottingham as a nucleus, a large and continually-increasing population has accumulated, mingling in its blood, as in its provincialisms, traces of more than one race of bygone times. Though, like its Bunter rock, the good old town of Nottingham is formed out of materials derived from a variety of sources, its elements have, like those of the rock, on which its ancient fortress stood, been none the less coherent; and to this day there is a remarkable public spirit among the people—an *esprit* founded on Nottingham associations—which reminds a stranger almost of the spirit which permeated the old clans. This, combined with the well-known impetuosity of the people upon political questions—resembling the rush of their noble river—has led some to compare them with the δημος of ancient Athens. And what better can one wish for them than that, while they eschew the vices, they may emulate the virtues, of that people in the best times of its history!

NOTE ON THE FLORA OF THE DISTRICT.

The study of a flora increases in interest when an attempt is made to correlate it with the geological formations. Although this has been attempted to some very small extent, it requires, in order to carry out the plan to any considerable degree of development, a far more minute and detailed acquaintance with the distribution of the flora of the district under review than the limited time at my disposal has permitted me to acquire. An attempt of this kind was made some time ago, under the auspices of the Literary and Philosophical Society of Nottingham, but little progress has, as yet, been made.

The commoner species of the Orders Ranunculaceæ, Cruciferæ, Geraniaceæ, Violaceæ, Caryophylleæ, Rosaceæ, Compositæ, Scrophularineæ, Labiatæ, Borragineæ, Euphorbiaceæ, Amentiferæ, Primulaceæ, Liliaceæ, Cyperaceæ, and Gramineæ, do not appear to be very partial in the selection of sites for their growth, and are distributed generally over the various formations; their distribution depending upon local accidents of habitat, or, in some cases, upon cultivation. In other instances, however, the case is different, and the species are more localised.

Of Ranunculaceæ, *Aquilegia vulgaris* grows wild, I believe, only in one place, and that on the limestone at Linby; while *Caltha palustris*, of the same Natural Order, is generally found flourishing in the moist alluvial flats of the Trent, the Leen, and the Erewash. The latter is true of *Cardamine pratensis*, among Crucifers, while *Draba verna* prefers the Bunter country, and is commonly found growing on the weathered surface of the rock itself.

Among Caryophylleæ, the *Lychnis* is decidedly partial in its growth; the red species (*diurna*) favouring the red marls, and the white species (*vespertina*), so common in the Chalk districts of the South of England, favouring the limestone country also here. *L. flos-coculi* is common only in the alluvial flats. Of the genus *Silene*, *S. nutans* (the "Nottingham catch-fly") is indigenous on the Castle Rock; while *S. inflata* seems to prefer the Permian and Coal Measure country.

Oxalis acetosella has a decided preference for the strong clayey soils, whether of the Coal Measures or of the Red Marl series.

Among Rosaceæ, I am acquainted with two species of the genus *Geum*; of these, *Geum urbanum* is to be found with its yellow star-like flowers peering out under every hedgerow in the month of June; while *G. rivale* is, I believe, confined to moist places on the Red Marls, the limestone country, and the alluvium of the Trent.

Saxifraga granulata flourishes equally on the Coal Measure, Bunter, and Keuper districts.

Of the genus *Campanula*, *C. rotundifolia* prefers the high and dry grounds of the Bunter; while *C. trachelium* appears to be confined to the limestone.

Lathrea squamaria I know only as growing at Linby on the limestone district.

The so-called "Forget-me-not," sold in quantity in the Nottingham flower-market, is not the species *Myosotis palustris* (the true flower of that name), but the smaller species, *M. arvensis*, which is very common on most of the country about here.

Of the genus *Primula*, *P. veris* is so plentiful on the high grounds of the Keuper that, with the country people, "Cowslip Sunday," as it is called, is (as I am told) a sort of annual "outing," in order to collect the flowers for the purpose of making an inferior sort of wine.

Among Orchidaceæ, *Listera ovata* (Twayblade) grows on Permian, Coal Measure, and Keuper soils; *Orchis Morio*, *O. mascula* and *O. maculata* on the Red Marl country; *Ophrys muscifera* and *O. apifera* on the Magnesian Limestone at Linby.

One species of Irideæ, *Crocus vernus* grows profusely in the "meadows" of the Trent Valley; and in the early spring they present, with their robe of purple, a most attractive appearance.

Paris quadrifolia flourishes both at Linby and on the Red Marls at Lambley.

Some of the caverns of the Church Cemetery have their walls almost brilliant from a vegetable coating which grows upon them. It is not a lichen, but a very small plant of the order Musci ("Phosphorescent moss" is its popular name). The delicate minute fronds of this plant allow the passage of a portion of the solar rays; while another and somewhat larger proportion is reflected from their glabrous surfaces. The moss is consequently luminous, whether viewed by a person looking into the cavern, or towards its mouth, though somewhat more so to the former than to the latter.

Railways have done much for the introduction of plants into new districts. In the course of their construction new soils are formed along the lines of the embankments; while the subsequent traffic scatters a variety of seeds, which often are not slow to attain a luxuriant growth in their new habitats.

VISIT TO THE BRITISH MUSEUM.

March 24th, 1874.

Directors:—Professor Maskelyne, F.R.S., and Professor Morris F.G.S.

On assembling at the Museum, the Members proceeded to the Mineralogical Department, where they were received by the Chief of the Department, Professor Maskelyne, who described a portion of the collection under his charge, especially noticing the rock-forming minerals.

The various forms of Silica, uncombined, notably Rock Crystal, Quartz, and Opal, were first noticed, and the splendid collection of crystals illustrating this group of minerals received due attention. The Earthy Carbonates were subsequently described, and after directing attention to the Hornblendic and Augitic groups, which, in common with every other class of minerals, are admirably represented in our great National Museum, the Professor dwelt upon the similarity of these two groups of minerals, which yet were characterised by important differences.

EXCURSION TO OXFORD.

April 6th and 7th, 1874.

Directors:—Professor Phillips, F.R.S., F.G.S., &c., and James Parker, Esq., F.G.S.

(*Report by* W. H. Hudleston, Esq., M.A., F.G.S., and James Parker, Esq., F.G.S.)

The party, consisting of numerous Members from the metropolis, and several from other parts of England, met in the New University Museum at noon. They were there most cordially received by Professor Phillips, who at once proceeded to announce the programme for the day.

This was a preliminary sketch in the Lecture-room by the Professor on the geology of the Middle Oolites, as developed in the neighbourhood of Oxford; demonstration by the Professor of the local collection in the Museum illustrating the above; lunch at the Professor's private residence; a walk to Shotover, under the guidance of Mr. Parker; tea and conversazione at the Professor's private residence in the evening.

On the assembling of the party in the Lecture-room, an extensive coloured diagram of the celebrated Shotover section greatly facilitated the exposition of the Professor's views, and enabled Members to form a good idea beforehand of the country they were to visit in the afternoon.

A very brief abstract of Professor Phillips' remarks may not be out of place. They were delivered with singular clearness and effect, and thereby afforded to those Members of the Association who were fortunate enough to be present on the occasion a rare opportunity of learning, from the great master of Mesozoic geology himself, some of the more salient geologic features of that country in which he has dwelt so long. "The valley, in which Oxford is situated, is cut down to the Oxford Clay, but there is, in most of the valleys, a quantity of low level gravel, which, in the promontory between Thames and Cherwell, on which the city stands, attains a depth of from 8 to 20 feet. In composition it is mostly oolitic, but with some admixture of materials from the high level gravel, which is often found capping the plateaux of the district. These materials are chiefly quartzites, felstones, and grits—flints are also found. Elephants' teeth are abundant. Therefore at a time when these gravels, which are of fluviatile or lacustrine character, were deposited, great herds of elephants must have roamed over the slopes bordering on the valleys of that district. There is no river action of the present Thames now in force which would produce such a deposit. The Oxford Clay hereabouts is of great depth, but appears to contain little or no trace of the Kelloway Rock, which, in Wiltshire on the one side, and in Yorkshire on the other, forms such a rich and characteristic fossiliferous zone towards the base of this series. Fossils are not particularly plentiful about Oxford—there are, however, several species of *Ammonites*. At a brickyard in St. Clements, a suburb of the city, many specimens of *Ammonites vertebralis* may be obtained. This is towards the top of the formation. It is succeeded by the Calcareous Grit, about 70ft. thick, a loose sandy rock, in parts cemented by carbonate of lime. The Coralline Oolite, or Coral Rag, which succeeds, is about 50ft. thick, and extremely full of fossils, especially of corals. Amongst these *Thecosmilia annularis* and *Isastræa explanata* are very numerous. From the position in which these masses are now found, it is not probable that they represent actual coral reefs, such as are at present growing in enormous vertical proportions in the Indian and Pacific Oceans; but rather that they are the result of drifted masses, like the Bermuda reefs, partially grown over by other corals and much frequented by Gasteropoda. The Echinodermata of this formation are well known for their beauty, but specimens are not so plentiful as in Wiltshire and Yorkshire. The spines of *Cidaris florigemma* are plentifully scattered about at Bullingden, &c., and some fine specimens of *Cidaris Smithii* are occasionally obtained. Brachiopoda are remarkably rare; but there is a goodly list of ordinary bivalves and univalves. *Lima* and *Pecten* are well represented. *Lima læviuscula* being remarkably fine and characteristic. *Chemnitzia Heddingtonensis* is most conspicuous amongst the univalves. Kimmeridge Clay, about 100ft. in thickness, rests immediately upon the hard Coralline Oolite, the surface of which appears to be water worn; a few feet above the junction there is a thin calcareous band. In the lower part occur selenite crystals of good size, clear and well formed; the upper parts are the most fossiliferous, and abound with the remains of saurians. *Ostrea deltoidea* is throughout the most characteristic fossil. The Portlandian beds, which succeed, consist mainly of sands, occasionally glauconitic, in which occur huge lumps of stone, seeming to be for the most part concretions round organic objects. Numerous Portlandian fossils occur in these. It is a remarkable circumstance as indicating the recurrence of a species, apparently extinct, that the beautiful little *Littorina muricata*, so characteristic of the Coralline Oolite, should, after the lapse of the entire Kimmeridgian period in this region, reappear as a Portlandian fossil. There seems, however, to be more than one instance on record of its occurrence in the Kimmeridge Clay itself. The Portland Sands are the last marine beds of the Oolitic System on Shotover Hill. They are covered, without any apparent disturbance of the sea-bed, by about 80ft. of the "Ironsand-series," the Oxfordshire equivalent of the Wealden, deposited probably near the rim of the basin. *Unio* and *Paludina* are of not unfrequent occurrence, though not likely to be found when no especial excavations are going on. A fern leaf was accidentally picked up by Mr. Brodie, and handed over before the value of the prize had been noticed. On another occasion Mr. Parker had caused some excavations to be made in a field at the top of the hill, when he stumbled on some very fine *Unios*. These beds contain a considerable quantity of ochre, but in the ochre pits little of importance seems to have been found. The iron ores are probably too siliceous to be of much economic value." Professor Phillips concluded his remarks by showing the great amount of denudation which the Oolitic and Wealden beds had probably undergone in some places before the deposition of the marine beds of Lower Greensand age, and instanced as a proof of this the accumulations at Potton.

The Professor then proceeded to point out in the Museum those portions of the collection illustrative of his lecture. Amongst many interesting fossils are some beautiful examples of *Ammonites catena*, a large ammonite (most probably *A. perarmatus*) out of which the shelly matter having been dissolved, the casts of the chambers hang loosely together like the links of a chain. These specimens are from the Calcareous Grit of Marcham.

After enjoying the Professor's hospitality, the party, under the direction of Mr. Parker, proceeded in the direction of Shotover to verify the sections just described, and did not return to Oxford till long after dark. Mr. Parker had coloured geologically a 4-inch-to-a-mile diagram of the district traversed. By the aid of this, and of Mr. Parker's explanations, the party had no difficulty in making out the geological bearings of the country previously described, as seen in the numerous pits and quarries on the route from Oxford to the top of Shotover hill. The party spent the rest of the evening with Professor Phillips.

On the following day, an early start was made. Professor Phillips personally conducted the party to Charlbury, and was ably assisted by Mr. Parker, who served out to each member a lithographic map of the valley of the Evenlode, on a scale of 4 inches to a mile, coloured geologically. These maps were made by Mr. Parker, for the purposes of this excursion.

The plan of the excursion was to walk from Charlbury to Handborough, a distance of 7 miles from W. to E. In the course of this stroll, starting from the Lower Lias, the following formations might be observed, viz.:—

		Ft.	In.
Marlstone		16	0
Upper Lias		10	0
Inferior Oolite		12	0
Great Oolite	Stonesfield Slate Great Oolite Forest Marble		
Cornbrash		6	0

On commencing to walk back from the Charlbury station, along the line, the party found itself in a cutting of Inferior Oolite, and the Members immediately proceeded to hunt for fossils. The Oolite here is a pale yellow ragstone containing a fair number of shells, belonging to the *Clypeus*-grit, which is probably the topmost member of the *A. Parkinsoni*-zone. *Terebratula Globata, (subglobosa?), Rhynchonella concinna, Myacites Jurassi, Pholadomya media (Ag.), Homomya gibbosa,* and *Clypeus Plotii* may be regarded as of frequent occurrence in these beds. Besides these, several others were found, as *Greslya*, another species of *Pholadomya, Ostrea crassa, Ammonites Parkinsoni, &c.* Some paler coloured and more fissile limestones, which in some parts of the cutting are observed to set in just above the ragstones, Professor Phillips was disposed to refer to the base of the Great Oolite. These seem to have yielded one or two teeth of *Acrodus?* to some of the party. A slight fall in the line on leaving the cutting, leads to lower beds opposite Fauler, where the Marlstone is being excavated for ironstone. Here there is a fine section, exhibiting the Marlstone, Upper Lias, and Inferior Oolite, one above the other, in most striking contrast.

The whole section cannot exceed 40 feet; this is all that represents beds, attaining at Cheltenham (30 miles to the west), a thickness of 600 feet. The Upper Lias consists of blue sandy clays, not known to contain fossils, and on this rests the yellow, rubbly Inferior Oolite. A most remarkable feature here is a thin bed of rolled shells and pseudo-pebbles, like the Dogger of the Yorkshire coast, and occupying an analogous position. Instead, however, of *Terebratula trilineata,* the chief shell here is *Rhynchonella tetrahedra,* of large size. This bed occurs exactly between the top of the Upper Lias and the base of the Inferior Oolite. It seems to partake of the colour and nature of the latter.

The party now bid farewell to Professor Phillips, who found it necessary to return, and proceeded in the direction of Stonesfield, under the guidance of Mr. Parker. The slaty beds of this portion of the Great Oolite occupy some highish ground between Fauler and Stonesfield. Mr. Parker pointed out the method of winning the slate. This is done by means of pits, into which the workmen descend to the bed whence the slate is extracted in galleries only a few feet thick. Piles of *débris,* the results of ages of work, encumber the hill side. By far the most characteristic fossil is *Trigonia impressa; Gervillia acuta* is also far from scarce. The party picked up several good things, and amongst others, a portion of a bone of a pterodactyl *Rhamphorhynchus Bucklandi*, was found.

One or two of the more adventurous of the party descended by means of a rope and loose ladder to the bottom of one of the "wells," to see the nature of the workings. On arriving at the village of Stonesfield, some little time was spent in looking over the specimens which the workmen brought. The scene from any of the numerous eminences is a very striking one. The enormous heaps of broken slates over which the grass does not grow meet the eye in every direction. From the time of the Romans, throughout the Middle Ages, the stone has been the chief roofing material throughout the district; but in consequence of the railway communication, it has found a serious rival in the Welsh slates, the extensive use of which threatens to put an end to the working of the pits here.

The party then descended by the eastern valley, close to the line of the old Akeman street, and regained the railway. Here some fine sections of Great Oolite, representing beds in the aggregate from 30 to 40 feet in thickness, were visible. The characteristic Great Oolite fossils were not abundant, but a bed of marl at one spot produced large quantities of *Nerinæa* (two species, *N. Eudesii* and *N. Voltzii*) and a small *Astarte*. A few specimens of *Terebratula maxillata* were found, but the remarkable bed of this brachiopod which occurs at Kirtlington is wanting, or at least is not exposed. The section along the railway is very interesting, but very difficult of interpretation. Going along the line one meets with what appear, at first sight, vast curved escarpments, with the Evenlode winding along the base, and so passing and re-passing the railway line. The strata, however, so far as they can be observed, are almost horizontal, and the series of cliffs (which have a general direction of north to south, while the main line of the Evenlode is west to east) must be accounted for in some other manner.

The party, leaving the rail, spent a short time in examining the remains of a Roman Villa. The outline of the chief quadrangle can be traced, though the foundations of the buildings are grassed over. One chamber alone remains tolerably perfect, with a very fine large tesselated floor, and a hypocaust beneath, and remains of the flues *within the wall*, especially by the side of a kind of alcove, at the north-west corner. A curious bath-chamber was also examined, where, besides what was probably a cold bath, remains of a small curved chamber, with flues round it, seemed to point to the luxury of what we now call a "Turkish Bath," but which appears to have been introduced here by some Roman officer of considerable wealth. The shells of the edible Roman snail *(Helix pomatia)* were found in great abundance. One of the large Roman capitals, the mouldings of which appeared as if only cut ten years ago, was examined, and it was decided that it was cut from a large block of Bath Oolite.

Within half-a-mile of Handborough Station the Great Oolite was lost, and was succeeded by the clays and shelly limestones of the Forest Marble. These were admirably exposed. The surface exhibited traces of fish, *e.g.* palates, teeth, and scales. A few shells, but as a rule imperfect. A thick bed of grey argillaceous shales, about 10 feet (not fossiliferous) separated these beds from the yellow rubble, above which is the Cornbrash, and which nowhere exceeds six feet in thickness. It did not in this place yield many fossils, but several specimens of the characteristic *Terebratula intermedia* were found scattered about.

The party reached Oxford about 5 o'clock, and there dispersed; a few Members, however, mustered in the evening at Mr. Parker's house, and inspected a portion of his cabinet of fossils, chiefly those which belonged to the district they had traversed during the two previous days.

POSTSCRIPT.—This excursion of the Association to Oxford will always have a melancholy significance for those who took part in it. None who heard the words and witnessed the vigorous actions of the veteran geologist who led the party through the Charlbury Cutting, could have anticipated that fatal stumble, which, not quite three weeks afterwards, deprived the Geologists' Association of a kind friend, and the world at large of an earnest and philosophic inquirer after truth.

ORDINARY MEETING, APRIL 10, 1874.

HENRY WOODWARD, ESQ., F.R.S., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

"Abstract of Proceedings of the Geological Society;" from that Society.

"Transactions of the Woolhope Naturalists' Field Club, 1869;" from that Society.

"Transactions of the Historic Society of Lancashire and Cheshire;" from that Society.

"Transactions of the Manchester Geological Society," Vol. xiii, Part 3.; from that Society.

"Report on the Exploration of the Brixham Cave," by J. Prestwich, F.R.S., F.G.S.; from H. W. Bristow, Esq., F.G.S.

"The Archetype and Homologies of the Vertebrate Skeleton," by R. Owen, F.R.S., F.G.S., &c.; from W. H. Leighton, Esq., F.G S.

"The Geometrical Isomorphism of Crystals," by the Rev. W. Mitchell, M.A.; from the Victoria Institute.

"List of Works on the Geology of Cambridgeshire," by W. Whitaker, B.A., F.G.S., &c.; from the Author.

The following were elected Members of the Association :—

Thomas Hayward Budd, Esq.; William Thomas Hustwitt, Esq.; William Wicks, Esq.; Herbert J. Pratt, Esq.; Gustavus Francis W. Larches, Esq.; Bernard Barham Woodward, Esq.; John Nicholas Carey, Esq.; William D. Latouche, Esq.; and Noel W. Reedston Read, Esq.

The following Paper was read :—

ON THE DAWN AND DEVELOPMENT OF LIFE ON THE EARTH.

By the President, HENRY WOODWARD, Esq., F.R.S., F.G.S., of the British Museum.

In "the East," that wonderful cradle of the human race, towards whose sunrise we turn to find the dawn at once of Civilization and Romance, Nature exhibits herself in all the exuberance of her vitality, both of plant and animal. The summer and the rainy season unite, with no intervening period of spring and autumn. Seasons, like days, spring suddenly into full-blown development. Night is succeeded by day without dawn, and day by night without the lingering hues of eve.

What wonder, then, that our ideas of Creation, derived as they undoubtedly were from Oriental tradition, should take the form of the opening of subtropical life rather than of our more graduated temperate zone; or that we should read of man and all animate creation springing suddenly into being from the rainy waste of chaos, each and all fully developed, as we behold them to-day!

"Nothing was in being," say the old men of an Indian tribe. "All was null and void; there was no sky, no earth, no sea, no shore; suddenly seven warriors found themselves seated on the edge of a lake, smoking the calumet of peace, and their wives were already working in the wigwams." No legend can more vividly bring before us the notion that man has passed his infancy as if in a dream. If for a moment we recall our own early recollections, we shall generally find they carry us back to some event, or place, or person, which filled our dawning intelligence, to the exclusion of all else, and beyond which we are unable to peer through the mist.

Turning from the consideration of our own impressions,—which, after the minutest self-investigation, would, unassisted by the guidance of friends older than ourselves, simply land us at the same conclusion arrived at by Topsy—"spect I growed"—let us learn how far History traces back the ancestry of our race and the changes of the world we dwell in. Alas! written documents do not carry us back more than thirty or forty centuries, whilst the most ancient remains of edifices, built at any previous epoch, which also may be called "*archives of stone*," date back perhaps 2000 years earlier; but far beyond this short historic period, which scarcely comprises the lapse of one hundred and fifty generations, extends a space of time, certainly far longer, known to us only by pure tradition. Mankind, already arising from its infancy to a more enlarged self-consciousness, had begun to link age to age by legends, poems, and symbolic formulæ. The reminiscences of great events, migrations, wars of races, alliances, exterminations, and triumphs of industry were incorporated into religion itself, and in an increasingly varied form were handed down from age to age as the heritage of nations.*

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* Reclus: English edition, edited by H. Woodward. "The Ocean, Atmosphere, and Life," Section ii., page 190.

In still more ancient times, in the dim mist of bygone ages, our ancestors lived the life of wild beasts in forests and caves.

Tradition, no less than history, is dumb as to this epoch of the human race; but by the labours of the geologist, we are beginning to learn somewhat concerning the habits and customs of these earliest ancestors of ours so long unknown to us.

If then History and Tradition cannot relate these earlier chapters in the infancy of mankind, but, like the efforts to recall the events of our childhood, are arrested by want of memory from telling us more, how powerless are they to inform us of those long lapses of ages when the lower animals already peopled this earth of ours—animals whose life-history probably extended over tens of thousands of generations before Man, the proud ruler of the earth, appeared upon the scene of his conquests!

How then can we ever hope successfully to trace the dawn of life upwards to its source through that long vista of ages comprised in the life of our planet, in comparison to which man's whole existence is but as a thing of yesterday? Truly the accomplishment of such a task seems at first sight far more remote in prospect than the discovery of the sources of the Nile.

What records can we search? What monuments explore? Has earth no sepulchre for the mighty save those erected by man to commemorate his short-lived fellows? Not so; every quarry by the road-side, every chalk-pit and brick-field are but so many mausolea, in which repose the hosts of living beings which peopled earth, air, or sea, in the old time, and, like the piled-up coffins in some ancient cemetery, they rise one upon another until they culminate in the snow-capped peaks of the Himalayas and the Andes, beside which the proud pyramid of Cheops seems but as a mole-hill.

Let us pry into this mighty charnel-house of Earth's great family, and strive, by the light which science lends us, to decipher some of the hieroglyphics, which tell to those who can read them aright the life-history of our globe. And here a wonderful historical parallelism presents itself to our minds between the early records of mankind and those of the earth's life-history; for just as the comparative labour of the palæographer increases the farther he carries his researches back into the remote past, encountering in turn Roman, Greek, Etruscan, Phœnician, Egyptian, and Assyrian characters, so in like manner the palæontologist passes gradually from the consideration of forms differing but little, if at all, from those living around him to-day, until he finds himself surrounded by a fauna and a flora, which, though broadly related to our own, yet differs so much in every detail that he fails at once to perceive that it has anything in common with that now existing. Yet comparative anatomy and comparative botany teach us that all the types of past life—like the early alphabets and symbols invented by mankind—can be brought into accord and correlated with existing types, and that in each case one system of classification is capable of embracing the whole.

In order rightly to understand the records of Earth's monuments, we must, in the first place, call in the geologist to explain to us such physical facts as are needful for us to become acquainted with before attempting to read its organic remains aright, each one of which may be looked upon as a hieroglyphic symbol which the palæontologist aims at deciphering.

From the geologist we learn that the great storehouses wherein the life-relics of the earth's past inhabitants lie embalmed are the sedimentary rocks. He tells us that these have resulted from the wear and tear carried on by meteoric agents of all those portions of the earth's surface elevated above the general ocean of the globe. We thus learn, that *from the very beginning* of life on the earth there must have been areas of depression and areas of elevation on our planet; the former occupied by the waters of the ocean, and the latter forming continents and islands exposed to all the influences of sun and wind, frost, snow and ice, rain and rivers, without which no sedimentary deposits could have been formed. Moreover, from an inspection of the organic remains themselves, preserved in the various rocks, we find that there were in former ages terrestrial plants and animals as well as fresh-water and marine forms of life, although the evidences of the last-named types are by far the most abundant.

Thus in the ancient submerged Forest-bed on the Norfolk Coast, in the Brick-earths of Ilford and Grays, in the Valley of the Thames, and in the London Clay, we have abundant evidence of old land conditions, the first being preserved as a land-deposit, the second as a fluviatile one "*almost in sitû*," the last named being an estuarine or *near-shore* deposit, formed at the embouchure of some large river, probably flowing, as the Nile does at the present day, from near the Equator in a north-easterly direction, watering a continent once occupying a part at least of the present site of the Atlantic, and perhaps embracing within its extent the Cape Verd Islands, the Canaries and Azores, all of which are volcanic, and mark an area of disturbance and oscillation of level which may have been more than once elevated and again submerged in very modern times.

But although, as already stated, these latter sedimentary deposits afford remains of animals and plants, which, with few exceptions, differ but little from those of the present day, yet it must be borne in mind that their geographical distribution has been greatly modified. For instance, referring back to the Norfolk Forest-bed and the Brick-earth of the Thames Valley, we find abundant evidence in the remains of elephants, rhinoceroses, hippopotami, &c., that the Eastern Counties were stocked with herds of quite another order from those which now occupy our pastures.

Again, in the Suffolk and Antwerp Crag are preserved immense stores of the bones of whales and other Cetacea, also remains of the huge *Dinotherium*, with tapirs and other land quadrupeds; whilst in the London Clay we have relics of abundant subtropical vegetation, evidenced by palm-wood and fruits, with remains of numerous extinct genera of animals, such as the *Palæotherium*, *Anoplotherium*, and *Xiphodon*, allied to the Tapir, Horse, Hyrax, &c., with many birds, including a large struthious bird of the size of the living Ostrich (*Dasornis Londiniensis*), and an aquatic bird with dentigerous mandibles, the *Odontopteryx toliapicus*; whilst the shores of the estuary and sea into which these remains of terrestrial life were carried was the home of *Crocodilia*, *Cheloniæ*, and sharks; with a Molluscan fauna rich in volutes and other sea-snails, and teeming with nautili, squids, and cuttle-fishes, like the warmer subtropical seas of the present day.

We have in the Eocene series in this country only a trace of the great Nummulitic formation which plays a far more conspicuous part than any other Tertiary rock in the solid framework of the earth's crust. On the Continent it becomes a great limestone formation, and attains a thickness of many thousand feet, rising in the Swiss Alps to a height of 10,000 feet above the sea. It occurs also in the Pyrenees, and extends from the Alps to the Carpathians, and is in full force in the North of Africa, as, for example, in Algeria and Morocco. In Egypt, the quarries in this rock near Cairo furnished the Pharaohs with building-stone for the Pyramids.* It extends into Asia, and across Persia, by Bagdad, to the mouths of the Indus. It occurs in Cutch, and in the mountain ranges which separate Scinde from Persia,* and forms the passes leading to Cabool. In Thibet it has been found at an elevation of 16,500 feet above the sea, and it has been followed as far as Eastern Bengal and the frontiers of China.

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* Herodotus mistook the nummulites in the limestone of the Pyramids for beans.

These vast masses of strata have resulted almost wholly from the accumulation of the shells of Foraminifera, one of the lowest forms of animal life belonging to the PROTOZOA, and to the same class as the *Eozoon Canadense*, to be alluded to presently.

Beneath these Tertiary beds, which partake most largely of the forms of life we see around us to-day, we come upon a set of strata known as the Cretaceous series, the thickest bed of which is the Chalk, which at some places attains a depth of more than a thousand feet, and covers an area as great as that of Europe.†

From certain prevalent organisms found in it, such as shells of oysters, ammonites, nautili, starfishes, and echinoderms, bones and teeth of fishes, geologists rightly conclude it to be a truly marine deposit.

But of what is the great bulk composed? Is it merely a finely comminuted white mud?—for such it seems to be to the unassisted eye. No; when washed and examined beneath the microscope, we find it to consist almost wholly of two distinct species of minute organisms.

The general mass of it is made up of very minute granules; but imbedded in this matrix are innumerable bodies, some smaller, some larger, but on a rough average not more than a hundredth of an inch in diameter, having a well-defined shape and structure. A cubic inch of some specimens of chalk may contain hundreds of thousands of these bodies, compacted together with incalculable millions of the granules.

The larger bodies when separated prove to be each one a beautifully constructed calcareous fabric made up of a number of chambers, communicating freely with one another. The commonest of these is called *Globigerina*, and sometimes seems to compose nearly the entire mass of the chalk.

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* A gigantic oval Nummulite (as large as a hen's egg), named *Loftusia Persica* by Messrs. Carpenter and Brady, was obtained in abundance by W. K. Loftus, Esq., in 1849-52 (during the progress of the commission appointed to demark the Turko-Persian Frontier), at Kellapstun Pass near Dú Púlum Bakhtiyari Mountains, Persia.—Phil. Trans. 1869, p. 739, pl. 77-80.

† In the youngest bed, the Maestricht Chalk, we find the *Mosasaurus*, a great lizard with formidable jaws, which once inhabited the valley of the Meuse. The *Leiodon*, Owen, from the Upper Chalk near Norwich, is closely allied to the *Mosasaurus*.

In the soundings carried out by Captain Dayman, R.N., in connection with the laying of the submarine cable between Ireland and Newfoundland, it was ascertained that almost the whole floor of the great central plain of the Atlantic, more than 1000 miles across from East to West, and which extends for many hundred miles in a North and South direction, is covered (at a depth of 1700 fathoms) by fine mud, which, when brought to the surface, dries into a greyish-white friable substance resembling soft grey chalk. When examined under the microscope, it proves to be composed of innumerable *Globigerinæ* (together with Diatoms) imbedded in a granular matrix.

Thus, then, this deep-sea mud is substantially like the Chalk. Professor Huxley (upon whom the task devolved of examining these deep-sea soundings) was surprised to find the "granules" of the mud in which the *Globigerinæ* abound had a definite form and size. He named these bodies *coccoliths*, but doubted their organic origin. Dr. Wallich, who accompanied Sir Leopold M'Clintock, in 1860, in the cruise of H.M.S. "Bull-dog," verified these observations of Huxley, and added the interesting discovery that not unfrequently bodies similar to these *coccoliths* were aggregated together into spheroids, which he termed *coccospheres*.

Mr. H. C. Sorby, F.R.S., in making a careful microscopic examination of the Chalk, observed, as Ehrenberg had done before him, that much of its granular basis possesses a definite form. Comparing these formed particles with those of the Atlantic soundings, he found the two to be identical; and thus proved that the Chalk, like the ooze, contains these mysterious *coccoliths* and *coccospheres*, as well as the shells of *Globigerinæ*. Professor Huxley has since traced out the development of the *coccoliths* from a diameter of $\frac{1}{7000}$ of an inch up to their largest size, which is about $\frac{1}{1800}$, and no longer doubts that they are produced by independent organisms, which, like the *Globigerinæ*, live and die at the bottom of the sea, at a depth of two miles beneath the surface.

There seems then to be good ground for the conclusion that the Chalk itself is the dried mud of an ancient deep sea, and, like the present ooze of the Atlantic, has been slowly accumulated in the abysses of the ocean. We thus see that the Chalk and the

Nummulitic Limestone are both largely formed of the dead shells of Foraminifera accumulated in deep and wide oceans, which once and again occupied the site of the present Old World continent.

But the Chalk furnishes remains of many organisms besides Foraminifera. It has afforded relics of some of the largest of those remarkable flying lizards, the *Pterodactyles*, at present met with; whilst the lower beds have also yielded one of the latest forms of land-lizards.[*]

Thus we have already extended our researches back sufficiently far to have met with *three extinct Orders*,—the *Pterosauria*, the *Plesiosauria*, and the *Dinosauria*,—which are only known to us in the fossil state.

The succeeding Greensand, Neocomian, Wealden, and Purbeck series yield us many more types of these extinct fossil Reptilian forms, and exemplify in a remarkable degree the changes in climate, and consequently in geographical distribution, which must have taken place to enable such animals to flourish in this country.

The rare shells of *Pleurotomaria*,[†] as also Brachiopoda, were exceedingly well represented in the Oolitic and Cretaceous rocks. Nor do we find many new Orders in the Oolitic series with which we are not already made acquainted in the more modern Cretaceous and Tertiary formations. The most interesting form is that of the *Archæopteryx*, a bird with a remarkable un-avian development of its caudal vertebræ, and possessing free wing-digits armed with claws. The head of this bird is wanting, but from the more recent discoveries of remains of extinct birds by Professor O. C. Marsh, in the Cretaceous beds of Kansas, we may reasonably presume that these earlier birds probably possessed mandibles armed with teeth.[‡]

The short-necked and massive *Pliosaurus*, which occurs both in the Portland Stone and the Kimmeridge Clay, affords us another type of those ancient and extinct sea-lizards once so numerous in the seas of the Mesozoic epoch; whilst the remains of the great *Cetiosaurus* and *Megalosaurus* testify to the magnitude of the land-reptiles of these Secondary rocks.

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[*] *Acanthopholis horridus*, Huxley.

[†] One living example has been obtained from the West Indies, and was valued by Mr Damon at £50. 400 species are known in a fossil state extending from the Lower Silurian to the Chalk.

[‡] Professor Marsh has discovered two—*Ichthyornis dispar*, Marsh, and *Apatornis celer*, Marsh, both from Kansas, U.S.A.

But whilst the Reptilia during the Mesozoic or Secondary Period increased enormously on the face of the earth, and in the waters, both in size and numbers, so as to have caused this period to be called "the Age of Reptiles," the Mammalia were *apparently* reduced to a few minute forms of Insectivorous Marsupials, known to us only from a rare series of their lower jaws discovered in the Purbeck beds and Stonesfield Slates, the largest of which was no bigger than the living Opossum.* Yet in speaking of the huge reptiles of the Old World, of whose colossal size we gather a notion from the cases containing their bones in the British Museum, and from the plaster restorations in the grounds of the Crystal Palace at Sydenham, how apt we are to overlook the fact that *the largest animals of the present day far exceed in size those of any previous epoch!* Where shall we find a fossil-lizard, whether of the land or sea, to vie with the great "Finner Whale" of our own day?—hugest of beasts that live, or ever have lived, disporting his eighty or ninety feet of bone, muscle, and blubber, with easy roll among the waves, secure from shipwreck in the stormiest sea.

The great class of Mammalia then to which we belong not only includes all the higher orders existing at the present day, but also the *largest living beings*, for the huge fish-like Cetacea are true warm-blooded air-breathers like ourselves, and are as assiduous in the care of their young as is the tenderest human mother.

In the Lias we meet with another type of extinct sea-lizard, the *Ichthyosaurus*, the remains of which have been largely preserved in England, especially at Lyme Regis, at Street, at Barrow-on-Soar, and Whitby.

This is the most fish-like of the lizards of the Mesozoic period, and must have been a veritable shark amidst the smaller fry, to judge by his terrible jaws armed with hundreds of conical teeth. Indeed, the contents of his stomach betray even a cannibal tendency, for when an hungered, he seems occasionally to have stayed his appetite till dinner-time with three or four baby Ichthyosaurs *au naturel!*

The great feature of the Mesozoic age was no doubt its *Ammonites;* but besides these it had a rich assemblage of *Trigoniæ*, a shell now only found living on the coasts of Australia, of

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* See Professor Owen's Monograph on the Mesozoic Mammalia, Pal. Soc. 1871, vol. xxiv. pl. i—iv.

Terebratulæ and *Rhynchonellæ*, of *Cidaridæ*, and of that beautiful form of Crinoid the "Bradford Pear-encrinite" *Apiocrinites Parkinsoni;* and, lastly, of king-crabs and other Crustacea, with dragon-flies and Cycadaceous plants. In the Vertebrate Classes it had its Chimæroid sharks, with palatal crushing teeth; its Pycnodont fishes; its *Ichthyosauria*, *Plesiosauria*, *Pterosauria*, and *Dinosauria;* its long-tailed birds; its all but oldest Mammalia yet discovered.

From this wonderful and rich display of life-forms we next pass over a long series of dreary almost unfossiliferous red sands and marls charged with gypsum and rock-salt, chiefly remarkable for the scanty evidences of another lost Reptilian Order *Labyrinthodonta*, helped out by abundance of foot-tracks of quadrupedal and bipedal reptiles, and some perhaps of birds (?). Some exceedingly minute teeth have also been obtained near Stuttgart, which are considered by Professor Pleininger to be those of a very small mammal, called *Microlestes antiquus*, believed to have been a minute plant-eating marsupial.

In the Muschelkalk a curious fossil, determined by Professor Owen to be a saurian and named *Placodus* (originally referred by Munster and Agassiz to the class Pisces), has been met with, which had palatal teeth, and fed no doubt on shell-bearing Mollusca, for crushing which its broad flat teeth seem well adapted. This Muschelkalk also yields a beautiful form of stone-lily (*Encrinus liliiformis*), also another genus of the Class Cephalopododa allied to *Ammonite*, named *Ceratites*.

Here geologists draw the line between Palæozoic and Neozoic.

The latest Palæozoic formation is the PERMIAN, a series of rocks not rich in fossils, but marked in this country by limestones rich in magnesia, often forming concretionary masses termed "botryoidal," and largely developed in Carinthia, where these Dolomitic limestones form vast pillar-like mountains, which have been compared to ancient coral reefs dolomitized and changed to stone, and lifted high and dry out of the sea, like some big wreck cast ashore, to tell of their former submergence. These Permian-beds are also largely copper-bearing in Germany, particularly in Thuringia. *Productus horridus*, *Spirifer undulatus*, and a few more shells, with branches of a coniferous tree, together with certain fishes, such as *Platysomus* and *Palæoniscus*, mark these beds.

Leaving, however, these comparatively barren rocks, we next come, in descending order, upon beds which must ever be looked upon as containing the most wonderful assemblage of fossil organisms in the entire stratified series—the Carboniferous system, with its Coal Measures, which attain, in the South-Wales Coal-field, an aggregate thickness of 12,000 feet, and comprise 100 seams of coal. Every one of these seams has its roof-shale and its under-clay. The roof-shale marks a break in the conditions of vegetable growth, decay, and accumulation caused by an inundation of foreign matter, probably introduced by a local subsidence of the area, to be again re-elevated, and again covered by a new forest of Carboniferous trees. Every under-clay is full of *Stigmaria*, the roots of the larger trees which contributed by their growth and decay to form the Coal.

What were the trees of the forests of the Coal Period? Were they oaks? or beeches? or pines? or gum-trees? or palms? No, none of these, but, strange as it may seem, humble Cryptogams were in this far-off period the precursors of the *Sequoia* and the Oak; the little Liverwort and humble Club-moss are the modern representatives of the *Lepidodendron* and the *Sigillaria;* whilst the common Mare's-tail or *Equisetum* of our ditches was then a giant *Calamite*, associated with vast numbers of ferns, some of which were arborescent in habit.

In its stagnant or slowly moving streams the *Archægosaurus* and *Anthracosaurus*, another type of Labyrinthodont reptile, moved, with *Baphetes*, *Pholidogaster*, and some thirty others of its kindred, whilst *Hylonomus*, probably an insectivorous reptile, may have ascended the trunks of trees in search of insects, remains of several of which have been discovered in the Coal.

Nor must we omit that besides a chilognathous myriapod (*Xylobius sigillariæ*), Dr. Dawson's labours have brought to light two air-breahing snails, *Pupa vetusta* and *Conulus priscus.*

Among the fossils foreign to the Coal itself, yet found associated with it in the clay-ironstone nodules of the Coal Measures, have been discovered numerous small king-crabs, a beautiful wing of a large locust, *Gryllacris lithanthraca*, and an entire arachnide from the Dudley Coal-field, *Eophrynus Prestvicii*, two scorpions and a spider from the Coal of Silesia, the *Protolycosa anthracophila.*

The Forest Marble of Wiltshire has the honour of furnishing the earliest-known short-tailed crab (the *Palæinachus longipes*), whilst the Coal presents us with the earliest-known lobster (the *Anthrapalæmon Grossartii*). Another form of nautiloid shell is also here met with, belonging to the genus *Goniatites*.

Beneath the Coal rests the Carboniferous Limestone, sometimes with the Millstone Grit between. The Carboniferous Limestone is for the most part a truly marine deposit, rich in corals and huge brachiopods, *Productus giganteus*, with large gasteropods, *Euomphalus*, *Macrocheilus*, etc., and with several species of trilobites—another truly extinct order of Crustacea (unless, as I have ventured to suggest elsewhere, the Trilobita are but a lower form of Isopoda, less highly developed and less differentiated than those of to-day). Abundant and beautiful forms of Crinoidea occur in these rocks, often forming entire strata of vast thickness by the fragments of their stems alone, as witness the Entrochal Marble and the "Screw-stone" beds of Derbyshire.* The Encrinite Marble is so extensive a deposit as to be quarried for mantelpieces and other economic purposes. This marble also yields a new type of nautiloid shell, but as it were unrolled and straightened out, the *Orthoceras*, one of the earliest of the Cephalopoda.

And here I may be permitted to observe that both at the outset in the Palæozoic rocks, and also in the Chalk, Gault, and Neocomian strata, near the close of the epoch of the Tetrabranchiate Cephalopoda (or four-gilled division of this Order of Mollusca), of which the *Nautilus* alone survives, they appear and disappear, as it were in contortions. In fact, these chambered shells assume the most varied curves, spirals, and discoidal twists conceivable, as if undergoing torture, or practising fashions. Nor can I divest my mind of the idea that the mimicry (as Dr. Darwin, Mr. Wallace and many other naturalists have pointed out) amongst animals of to-day was practised at a very remote period, and by very different forms of life. Thus in the age of the Solenhofen Limestone I believe long-tails must have been set forth in the fashion-book of the period; for we have a long-tailed bird, the *Archæopteryx*, a long-tailed Pterodactyle, the *Rhamphorhynchus*, a long-tailed crab, the King-crab. Tails among reptiles have been mostly in vogue—the earlier frogs even wore tails, and their babies keep up the remembrance yearly, but drop them as soon as they come ashore.

Here we take leave of our Reptilian friends, and go on further back in time, with only fishes to remind us of *animals with backbones*. But swelling with the portents of future races, which shall arise to call him ancestor, behold the giant *Pterygotus*—largest of Palæozoic Crustacea, rivalling in size even the existing *Inachus Kæmpferi* from Japan, and far more muscular. Doubtless in his day, both in the Upper Silurian and in the Devonian, he played an important part, devouring all things which came in his way, both old and new, living and putrid; like the existing members of his family, he had not a high stomach!

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* The *Woodocrinus*, a beautiful form of stone-lily, only occurs at one particular locality, in the Carboniferous Limestone near Richmond, Yorkshire.

Still evidences of land! Mr. Samuel Scudder, of Boston, has described several Devonian insects; Dr. Dawson, of Montreal, Mr. Baily, of the Irish Survey, the late Professor Forbes, and others, have described several Devonian land-plants. Corals, as in the Carboniferous Limestone, were plentiful, and many formed reef-like masses of great size and compactness. A peculiar form of trilobite, with a large fan-tail (*Bronteus flabellifer*), and more brachiopods.

The fishes have a tendency to imitate king-crabs; their bucklers are peculiarly Crustacean-looking, another case of mimicry: who set the fashion? and who followed?

Judging by the numbers of trilobites and crinoids, we have reached the "Kingdom of Siluria," and behold the rich treasures of the Wenlock Limestone, its stores of Brachiopoda, its oldest king-crab, *Neolimulus falcatus*, its queer *Pterygoti*, its corals and earliest remains of fishes. But time would fail to tell in detail the fauna of each rock of Ludlow, Wenlock, Woolhope, Llandovery, Caradoc and Bala, Llandeilo and Arenig, each a world of ages in antiquity, but still full of Crinoidea, starfishes, trilobites, and lampshells, with varied forms of Orthocerata.

And now, wreathed in *Graptolites*, comes the Cambrian, with its slate-rock, and more new trilobites, a starfish and a crinoid, *Lingulæ* and zoophytes. Again rock-mass succeeds to rock-mass: Tremadoc Slates, Lingula Flags, Harlech Grits, Llanberis Slates. Is this the last? No, emphatically. Sir William Logan in Canada has added yet another conquest, and brought in the great Laurentian kingdom, with its 30,000 feet of sedimentary deposits, and its (as yet) single fossil, the *Eozoon Canadense.*

What is this *Eozoon Canadense*? This to us, at present, oldest known form of life.

I have already spoken of the "Nummulitic Formation," a limestone of Eocene Tertiary age, extending from England to China in a broad band, and in thickness sufficient to help to build up the Pyrenees, the Alps, the Atlas Mountains, the Carpathians, and even the mountains of Asia, extending into China and Thibet.

This limestone is made up largely (often entirely) of the lenticular shells of *Nummulites*. Instead of shells, imagine it one shell, one animal, and you have a notion of what *Eozoon* is like.

I have told you of the Chalk, covering an area as large as Europe, being largely composed of the shells of a microscopic genus of Foraminifera called *Globigerina*. Instead of many shells, imagine it one shell, and you have a notion of what *Eozoon* is like.

But you will probably say, "This is too much to ask one to accept; the idea of a kind of common composite animal, however simple, stretching from the shores of Labrador to the margin of Lake Superior, and thence northwardly to an unknown distance, constituting a wild and rugged region, often rising into hills 4,000 feet high, and forming cliffs 1500 feet sheer vertical depth!"

Let us instead look for a moment at the Pacific Ocean. Not an island in the intertropical region that lifts its head above the wave but is made of or fringed with coral reefs. Florida and the West Indian Islands, as well as those of the Indian Ocean, within the Tropics, are alike coral-bound or coral-built. Here then, I think, we shall find a parallel instance, derived from a higher grade (the Zoophyta), in which composite animals are world-makers on fully as large a scale as the *Eozoon Canadense*, if not larger.

Speaking of the Atlantic mud, Professor Wyville Thomson, writes: "The mud was entirely filled with the delicate siliceous root-fibres of the vitreous sponges, binding it together, and traversing it in all directions like hairs in mortar. *This mud* (he goes on to say) *was actually alive*; it stuck together in lumps, as if there were white of egg mixed with it, and the glairy mass proved under the microscope to be living sarcode. Professor Huxley regards this as a distinct creature, and calls it "*Bathybius*." Wyville Thomson inclines to look upon it as "simply a sort of diffused *mycelium* of the different distinct sponges growing at the bottom." "This view," he adds, "accords well with the mode of nutrition of the sponges."

This *Bathybius* agrees exactly with Huxley's description of his universal basis of life, or *Protoplasm*, which he traces in so many and various bodies, and which behaves like an ordinary *Amœba*, "drawing in and thrusting out prolongations of its substance."

Whether the so-called *Protoplasm* is, or is not, the ultimate basis of life,—whether it grows naturally from dead matter on which it feeds, as the brewer supposes the beer or wine to feed on the lees,—whether it can be made as a chemical compound from the elements of which it is composed,—we are not yet prepared to state. But I have been enabled to show you in a very rough and hasty way—(1) That the oldest organism with which we are acquainted is one of the simplest, being an aggregate of a number of Foraminifera associated together so as to form a common Protozoan reef, just as a coral island is a Zöophytan reef. (2) That the Chalk and Nummulitic Limestone have been similarly built up of aggregations of the calcareous skeletons of myriads of Protozoans filled with sarcode, or *Protoplasm*, as the *Eozoon.* (3) That each geologic period as we ascend stage by stage upwards in the chronology of our Earth does not point to a periodic *re-creation of all things*, but rather tends to show that a gradual development of life has been taking place ever since its first appearance.

We have not a perfect and complete history of life on the globe, nor is it a thing to be ever expected. Geologists have learned to say "we don't know" about a great many things which at one time they either thought they did know, or they were credited by their friends with knowing.

But making every allowance for our ignorance of past life-periods, and also for the imperfection of the Geological Record, I think it can be clearly demonstrated that there is "*a continuity of life on the earth*" from the earliest dawn of that life to our own day: that the changes which have taken place have resulted from alterations in physical conditions, such as the elevation and subsidence of the land, bringing out changes of climate, causing migrations and modifications in distribution, in numbers, size, etc. That from period to period, in the far-off past, the various groups have in turn prevailed as leaders in the kingdom of animal and vegetable life. Thus in early times the Cephalopoda ruled, later on the Crustacea came to the fore, then probably Fishes took the lead, but were speedily overpowered by the Saurians. These land and sea reptiles then prevailed until Mammalia appeared upon the scene, since when it doubtless became a struggle for supremacy until Man was created. Then came the age of *invention;* at first of flint and bone implements, of bows and arrows and fish-hooks;

then of spears and shields, swords and guns, lucifer-matches, railways, electric telegraphs; since when even the great whale has given in his adhesion to the new king, Steam, and is dying out of the way quietly.

One fact more deserves to be borne in mind: that is, the immensity of time since life first began. Originally only Plutonic or Eruptive rocks existed. As these yielded to weathering, they produced sediments which assisted to form the very earliest stratified rocks. Again, these in their turn were denuded wherever elevated above the sea, and assisted to form by their wreck the Palæozoic strata, from all of which the Secondary and Tertiary formations have in like manner been made. But animals, by their labours and accumulated skeletons, have probably contributed more largely than any other source to build up the masses of the sedimentary rocks. Nor is it to the highest in the zoological scale that this task of mountain-building has been entrusted by Nature; on the contrary, the two humblest classes the PROTOZOA and CŒLENTERATA, have been chosen to rear these imperishable monuments; whilst our great stores of mineral fuel, upon the *continuity* of which the vast industries of this country depend, are the result of the accumulated growth and decay of lowly organized Cryptogamic plants, allied to our existing club-mosses and Equisetaceæ.

VISIT TO THE BRITISH MUSEUM.—APRIL 18TH, 1874.

Director—PROFESSOR MORRIS, F.G.S., Honorary Member of the Geologists' Association.

The portion of the Natural History Department of the Great National Museum devoted to the display of the Mollusca, was visited on this occasion by the Association. The more prominent of the distinguishing characters of the principal divisions or Classes of the Sub-kingdom Mollusca, were described by the Director, who illustrated his lecture by the beautiful specimens, which are so well preserved and so well shown in the cases.

EXCURSION TO LEWISHAM.—April 25th, 1874.

Director—William Whitaker, Esq., B.A., F.G.S.,
Of Her Majesty's Geological Survey.

The section at Loam Pit Hill, where the Woolwich and Reading Series is well displayed, almost monopolised the attention of the party. On reaching the excavations, the Director gave a general description of the Series as exhibited in the Woolwich district and in the neighbourhood of Reading respectively, and pointed out the special features of the section. The details, taken from Mr. Whitaker's "Geology of the London Basin," page 127, are as follows :—

London Clay.

1. Brown Clay, the lower part roughly laminated, about 15 feet on the north, increasing southwards with the dip (about 3°).
2. Basement Bed. Flint pebbles, with clay and sometimes sand, thickening southward from two inches to a foot or more, resting evenly on the bed below.

Woolwich Beds, about 50 Feet.

3. Light-coloured sand, with partings of clay. At one place a little thin friable buff stone just at top. Near the top a well-marked bed of loose, very light-coloured sand, about 4 inches thick, which makes more plain small faults (from 2 to 9 inches downthrow) about 10 feet, passing down into

3* Laminated Clay, with partings of sand, and with a little selenite. Near the middle many leaves occur. A little below the leaf-bed there is a 4 or 5-inch layer of small flint-pebbles (*a*), below this is a lignite-bed (*b*), 3 to 6 inches thick, sometimes with a layer of iron pyrites containing casts of shells; and at one part a sandy lignite at the bottom. Over 10 feet.

4. Brown Sand, about 3 feet.
5. Sandy Clay, about 2 feet.
6. Clay Shell-bed (*Cyrena*), 1½ feet.
7. Oyster-bed, 2 feet.
8. Clay Shell-bed (*Cyrena*), a few flint-pebbles at bottom, 1½ feet.
9. Yellowish Clay, with race and soft calcareous matter, 1 ft. 5 in. (less in parts).

10. Pebble-bed, sandy; the pebbles irregularly arranged (not bedded). ? False bedded in parts, red at the top part, over 12 feet.
11. Bottom Bed. Light-coloured sand, with layers of flint pebbles, at the bottom part greenish sandy clay and clayy sand with a few pebbles; 6 to 8 feet, resting on a worn surface of the next bed.

THANET SAND

12. Thanet Sand, the uppermost 6 or 8 feet, yellowish and iron stained, then 20 feet or more with a pale pinkish-grey tint, total thickness probably 40 feet. Green-coated flints at the bottom, resting regularly and conformably on

CHALK WITH FLINTS.

At the conclusion of Mr. Whitaker's lecture, Professor Morris, who was present, addressed the Members on the significance of this important section, which, in itself as it were, illustrates and teaches the geology of the Thames Valley, since it shows all the beds from the Chalk to the London Clay, and is so situated that the observer may from the neighbouring ground survey without difficulty the valley flats of deposits of Pleistocene age.

ORDINARY MEETING, MAY 1ST, 1874.

HENRY WOODWARD, Esq., F.R.S., F.G.S., &c., President, in the Chair.

The following Donations were announced:—

"On the Bone Implements, &c., from the Caves of Perigord, France," by Prof. T. Rupert Jones, F.R.S., F.G.S.; from the Author.

"Abstracts of Proceedings of the Geological Society;" from that Society.

The following were elected Members of the Association:—

Augustus Wildy, Esq.; George Simonds Boulger, Esq.; J. Wheatcroft, Esq.; and Charles William Rothery, Esq.

The following Papers were read:—

1. OBSERVATIONS ON SOME CARBONIFEROUS POLYZOA.

By ROBERT ETHERIDGE, ESQ., jun., F.G.S.

The following observations consist of a few notes on certain Carboniferous Polyzoa which have come under my notice during some investigations into the structure of various members of the Class more commonly found in the Scotch Carboniferous Limestone series.

GENUS SYNOCLADIA, *King*, 1849.*

Until recently *Synocladia* was known in this country only from rocks of Permian age, as one of the characteristic corallines (*S. virgulacea*, Phill.) of the Magnesian Limestone. In America, however, a species has been recognised in various portions of the Carboniferous series, originally found in, and described by Professor Swallow, from the Lower Permian strata of the Cottonwood Valley, Texas, under the provisional name of *S. biserialis*.† (Figs. 1 and 2).

In general habit this agrees with the typical *S. virgulacea*, but in some of the more essential characters differs widely.

In the "Palæontology of Eastern Nebraska," ‡ Mr. F. B. Meek has figured and described this fossil from various horizons in the Carboniferous strata of that state, Texas, and Iowa, giving the specific characters in greater detail than Professor Swallow had done in provisionally applying his name. Mr. Meek further gives good and sufficient reasons for regarding *S. biserialis* as a separate species, distinct from *S. virgulacea*, a point on which some doubt had been cast.

In the September number of the *Annals and Magazine of Natural History*,§ I described a Carboniferous species of *Synocladia*, under the name of *S. carbonaria* (Figs. 3 and 4), which at that time I took to be quite specifically distinct from any described species, but through the kindness of Professor W. King, who has favoured me with photographs of American specimens (Figs. 1 and 2), and extracts from Mr. Meek's previously quoted work, I have ascertained that our Scotch Polyzoon must cease to be regarded as a distinct species, but may be considered as a well marked variety of the American Permio-Carboniferous *S. biserialis*, Swallow, under the varietal name of *carbonaria.*[*]

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* *Annals and Magazine of Natural History*, 2nd ser., vol. iii., p. 388.

† *Transactions St. Louis Academy of Natural Sciences*, vol. i., p. 179.

‡ Washington, 1872, p. 156.

§ 1873, vol. xii., 4th ser., p. 189.

It was only whilst my notice of the Scotch variety was in course of printing that I had access to Mr. Meek's description of *S. biserialis*; it therefore becomes satisfactory to find that the two independent descriptions more or less closely corresponded.

As in the typical *S. virgulacea*, the frond is composed of numerous rib-like stems, rising from a common root and frequently bifurcating; the branches or dissepiments are short and simple, and spring at an ascending angle from one stem to meet those of the opposite stem, and thus form the peculiar arch-like dissepiments so characteristic of the genus (Fig. 3). The latter occasionally lose their normal form, and become mere ordinary connecting bars, so enclosing irregular fenestrules; this is more apparent in the lower parts of the frond towards the root. The two species, *S. virgulacea* and *S. biserialis*, including the variety *carbonaria*, differ essentially in the arrangement of the cells on the celluliferous or obverse face. In the former the cells are placed on the stems in from three to five furrows, separated by angular keels, on which may be seen small papillæ-like elevations or projections ("gemmuliferous vesicles" of King), whilst on the branches the cells are restricted to two rows with a dividing keel, those of one row set alternately with those of the other. In the latter, on the other hand, there are only two rows of cells on both stems and branches, separated by a keel set with "gemmuliferous vesicles" as in *S. virgulacea* (Fig. 5). Furthermore, scattered in a most irregular manner amongst the cells proper, are a number of supplementary cells, without any attempt at definite arrangement; these may be easily distinguished by their much smaller apertures. Again, the papillæ-like elevations to which Professor King has given the name of "gemmuliferous vesicles,"[†] are found in *S. virgulacea* only on the keels of the stems, whilst in *S. biserialis* they are continuous from the keels of the stems to those of the branches (Fig. 5). Lastly, the reverse face of the Carboniferous form is striate, and scattered over it here and there, generally however at the setting off of the branches, are additional cell apertures (Fig. 3). I do not think that any structure of this description is to be seen on the reverse of *S. virgulacea*, which, according to Professor King's figure,"[‡] is plain, and non-striate; perhaps, however, the absence of striæ, may be due only to the state of preservation of the specimens from which the original descriptions were made.

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[*] *Memoirs Geological Survey*, *Explanation* 23, *Scotland*, 1873, p. 102.

[†] *Permian Fossils*, 1850, p. 37.

[‡] *Permian Fossils*, plate 4, fig. 8.

From an examination of indifferent specimens I was led, in my original description, to attribute these supplementary cells on the reverse face of *S. biserialis* and variety to the broken bases of the "root-like processes" met with on the reverse face of *S. virgulacea*, but I now believe that my conjecture was wrong, and that they are, perhaps, true cells in the same sense as those on the obverse face.

So far as I am able to judge, without an actual comparison of specimens, the Scotch fossil appears to present a more irregular method of branching than that seen in the American *S. biserialis.* It is principally on this account that I regard the former as a variety of the latter. I am the more inclined to this, as I find Mr. Meek appears to regard the *Septopora Cestriensis*, Prout,* from the Upper Archimides Limestone of Chester, Illinois, as a synonym of *Synocladia biserialis.* From the late Dr. Prout's description, this appears to differ only from a typical *Synocladia* in having the branches or dissepiments more celluliferous (cells in from one to four rows) than the stems or interstices (cells in two lines). Should *Septopora Cestriensis* be only a synonym of *Synocladia biserialis*, the larger number of cells on the dissepiments would be another point in favour of the Scotch fossil being considered a variety, for in all specimens which have come under my notice, the cells were found to be constantly in two lines only, one on each side of the median keel.

There is one specimen in the Geological Survey collection in which one of the stems is stronger than the others, and from which the latter take their rise, closely resembling the general habit of *Ptylopora pluma* (Scouler), McCoy,† but still retaining the intermediate arch-like dissepiments. The following is a brief diagnosis of the British specimens:—

SYNOCLADIA BISERIALIS, *Swallow*, var. CARBONARIA, *mihi; S. carbonaria*, R. Etheridge, jun. (Annals and Mag. Nat. Hist., 1873, 4th ser., Vol. xii, p. 189, pl. 10); *S. biserilais*, Swallow (Pro. Acad. Nat. Sciences, St. Louis, Vol. i., p. 179); var. *carbonaria*, R. Etheridge, jun. (Mem. Geol. Surv., Expl. 23, Scotland, 1873, p. 102).

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* *Transactions Academy Natural Sciences, St. Louis*, vol. i., p. 448, pl. 18, fig 2.

† *Synopsis Carboniferous Fossils*, 1844, p. 200, pl. 28, fig. 6.

Polyzoarium, a plumose expansion, springing from a common root of attachment. Interstices or stems, rib-like, frequently bifurcating, much stouter and stronger than the branches; obverse celluliferous, with a rounded median keel; reverse round and striate; dissepiments or branches short; opposite halves given off at an oblique angle from their respective stems, which meeting give rise to arched or reversed V-shaped branches; obverse angular and celluliferous; reverse rounded and striate, sometimes becoming modified into stems. Dividing ridges or keels, on the obverse face of both stems and branches, separating the two lines of cell-apertures, those on the stems rounded, those on the branches slightly angular. Fenestrules arch-shaped when the stems and branches assume their normal character, otherwise irregular. Cell-apertures arranged in two alternating lines, both on the stems and branches, separated by the median keel, and with prominent margins. Supplementary cell-apertures scattered irregularly amongst the primary cell-apertures, either singly or grouped in twos and threes, whilst open or closed papillæ-like protuberances are placed on the keels of both stems and branches, apparently alternating with the cell-apertures. Reverse, regularly and finely striate, rounded; scattered over the surface are open wart-like projections, or papillæ probably cell-apertures. These are often placed at the setting off of the branches, and sometimes at the apex of the V-shaped arch.

Localities.—Lower Carboniferous Limestone Group—Shale over the Gilmerton Limestone, Gilmerton, near Edinburgh; Shale between the 1st and 2nd Calderwood Limestones, Calder Water, opposite old mines of Calderside and Newfield Quarry, both near East Kilbride, Lanarkshire; Shale connected with the Raesgill Ironstones, Wilton Ironstone Pit (Coltness Iron Company), near Carluke (collection of the Geological Survey of Scotland, collected by Mr. J. Bennie).* Upper Carboniferous Limestone Group—Shale between two beds of Limestone, Mouse Water, opposite Lambcatch, near Wilsontown, Lanarkshire; Shale above a bed of limestone, near Laigh Longridge, Stonehouse, Lanarkshire (Collection of the Geological Survey of Scotland, collected by Mr. A. Macconochie).

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* Dr. Rankin, of Carluke, has obtained *S. biserialis*, var. *carbonaria*, from the shale in connection with the Lingula Ironstone of that district, which he kindly allowed me to examine.

GENUS POLYPORA, *McCoy*, 1844.*

McCoy proposed this genus for those flat and fan-shaped Carboniferous Polyzoa, with the general habit and appearance of *Fenestella*, but distinguished from the latter by the absence of any median keel on the interstices, and the presence always of more than two rows of cells, which are, however, as in *Fenestella*, confined to the interstices, and do not occur on the crossbars or dessepiments.

In a paper read before the Geological Society,† "On some Fossils from India, &c.," Professor de Koninck described several new species of Polyzoa from the Carboniferous rocks of the Punjaub. In his description of *Polypora fastuosa* attention was drawn to the internal characters of the cells, which appear to be arranged on the same plan as that seen in *Fenestella* or *Synocladia*, where they spring from the basal plate of the polyzoarium in an obliquely inclined direction, curving outwards to the surface of the interstice, where they open parallel to the immaginary axis.‡

In a specimen of a *Polypora*, from Longniddry Quarry, Haddingtonshire, I observed the position of similar papillæ-like elevations, as in *Synocladia* and other genera, called by Professor King "gemmuliferous vesicles." These, in the specimen referred to, are placed one over each cell aperture, a little to the right side of the cell, and are very prominent, still, however, retaining their wart-like character. In another specimen of a *Polypora*, from Hairmyres Quarry, Lanarkshire, in the Geological Survey collection, these little bodies are found to occupy a somewhat different position—placed in linear series between the rows of cells, arising from the ordinary surface of the dissepiment.

GENUS THAMNISCUS, *King*, 1849.§

A genus of Permian Polyzoa in which the stems or interstices frequently and irregularly bifurcate at their distal extremities, the dessepiments are free, and the gemmuliferous vesicles overlie the cell apertures.

In addition to the typical species *T. dubius*, Schlotheim, there is a Carboniferous coralline indicated by Professor King‖ as probably congeneric, the *Fenestella intertexta*, Portlock.[*] In this species the growth commenced from a centre, resulting in thick interstices or branches, forming by anastomosis very irregular fenestrules, and in all probability free at their extremities. Lastly, the Chevalier D'Eichwald has described a third form of this genus from the Orthoceratite Limestone of Erras, Russia, under the name of *T. bifidus*.[†] It appears to be characterised chiefly by the lateral branches arising from one side of the principal stem only; the cell apertures are round, and arranged in quincunx.

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* *Synopsis Carboniferous Fossils*, 1844, p. 206.

† *Quart. Journ. Geol. Soc.*, 1863, vol. xix., p. 1.

‡ Ibid pl. 1, f. 4a.

§ *Annals and Magazine of Natural History*, 2nd ser., vol. iii., p. 389.

‖ *Permian Fossils*, p. 44.

Amongst many other Carboniferous Polyzoa collected at Longniddry Quarry, Haddingtonshire, by Mr. D. J. Brown, of Edinburgh, was one slab of shale with, weathered out on one of its surfaces, several fragmentary, but well preserved specimens of a species of *Thamniscus*. Unfortunately in each case the non-celluliferous face is presented to us, so that the precise specific identity remains somewhat doubtful. Nevertheless, the general characters are such as to place the Longniddry specimen close to *T.* (*Fenestella*) *intertexta*. The stems and branches (Fig. 7) are thick and robust, frequently bifurcate, are rounded, and the termination of many of the branches in the upper part of the specimens are free, whilst towards the root or base they join, and so form more or less irregular fenestrules. Of the three species mentioned, our *Thamniscus* is certainly very nearly allied, if not identical with Portlock's species, but until specimens showing the characters of the celluliferous face are preserved, it would not be wise to definitely refer it to the latter. It is delicately striate.

It becomes an interesting fact to note the increasing number of forms which are gradually becoming recognised as common in our own country to the Carboniferous and Permian Systems. On the Continent Dr. Geinitz and M. Göppert have indicated the large series of plants common to the two groups, whilst in this country the researches of Mr. Davidson,[‡] Professor King,[§] Mr. J. W. Kirkby,[‖] and many others have thrown much light upon the specific relations existing between the Brachiopoda, Entomostraca, and other Classes of the Carboniferous and Permian faunæ. In America this comparison has extended to perhaps a greater extent than elsewhere, as may be seen by a perusal of the writings of Dr.

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[*] *Geological Report, Londonderry*, 1843, p. 324, pl. 22 A., fig. 3, a, b, & c.
[†] *Lethæa Rossica*, 1860, vol. i., p. 386, pl. 23, f. 17, a & b.
[‡] *Monograph of Carboniferous Brachiopoda, Pal. Soc.*
[§] *Edinburgh New Philosophical Journal*, vol. xiv., p. 37, xv., p. 251.
[‖] *Annals. and Magazine of Natural History*, 3rd ser., vol. x., p. 202.

F. B. Shennard, Mr. F. B. Meek, the late Dr. Prout,* and other authors. The occurrence of a variety of *Synocladia biserialis*, Swallow, in our Scotch Carboniferous beds, adds another link in Great Britain to the chain of evidence which tends to unite the Carboniferous and Permian, and from its occurrence in American rocks is a point of some interest. A well-digested account of the species common to British Carboniferous and Permian Rocks will be found in a paper by Mr. J. W. Kirkby, " On some additional species that are common to Carboniferous and Permian Strata; with Remarks on the Recurrency of Carboniferous species" *(op. cit.)*. In conclusion I have to thank my friend Mr. H. M. Skae for the very careful drawings which accompany these notes.

Description of the Figures.

Fig. 1.—*Synocladia biserialis.* Swallow. Obverse face, showing the arrangement of the cell-apertures, and other characters.

Fig. 2.—Reverse face of the same. Both these figures are taken from enlarged photographs of American specimens, for which I am indebted to the kindness of Professor W. King.

Fig. 3.—*Synocladia biserialis,* Swallow, var. *carbonaria.* R. Eth. Jun. Reverse face, enlarged three diameters, showing the arch-like form of some of the dissepiments, and the scattered supplementary cell-apertures. From the shale over the Gilmerton Limestone, Gilmerton, near Edinburgh (Lower Carboniferous Limestone).

Fig. 4.—Reverse face of another specimen from the same locality, natural size.

Fig. 5.—Portion of obverse face of another specimen, showing the cell-apertures, and the papillæ on the keels. From shale between the Calderwood Limestones, Calderside, East Kilbride, Lanarkshire. Enlarged six diameters.

Fig. 6.—Another portion of the same taken from near the root, showing the large cell-apertures, and smaller supplementary cell-apertures. From same locality. Enlarged six diameters.

Fig. 7.—Reverse or non-celluliferous face of a portion of *Thamniscus* sp. From shale of the Lower Carboniferous Limestone Group, Longniddry Quarry, Haddingtonshire. Enlarged four diameters.

2. On Some Geological Puzzles.

By Edward Charlesworth, Esq., F.G.S.

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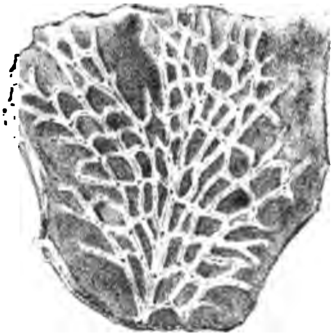
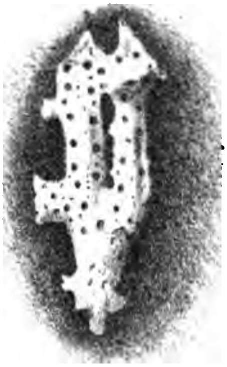
* *Transactions of the Academy of Natural Sciences, St. Louis,* vol. i., p. 440.





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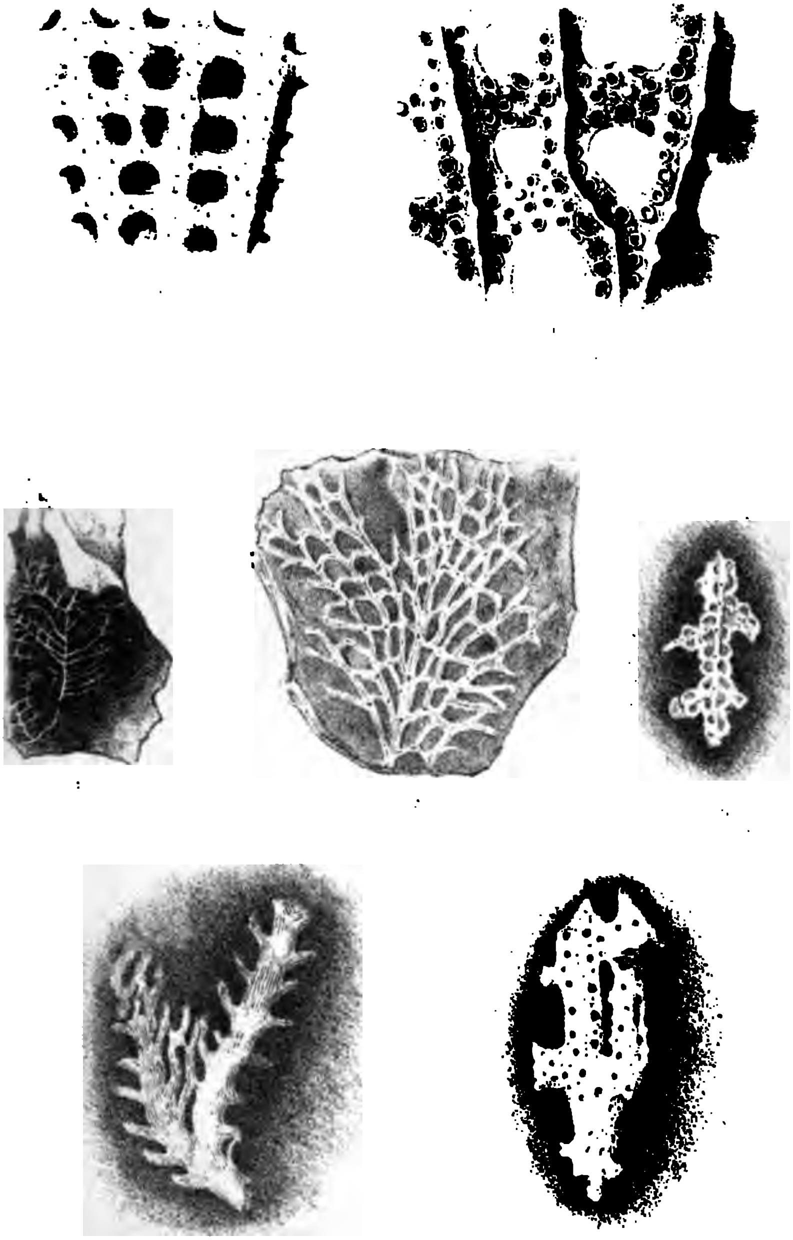

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Carboniferous Polyzoa.

EXCURSION TO GRAYS, ESSEX.—May 16th, 1874.

Director—Henry Walker, Esq., F.G.S.

(*Report by* Mr. Walker.)

A large party left the Fenchurch-street Station, to visit the exposures of the Mammalian Beds of the Lower Thames Valley, and sections of the Upper Chalk, at Grays. The pits at Little Thurrock, so celebrated for their Pleiostocene fauna, were first visited. Here the picturesque and typical section of false-bedded sands, eighteen feet in thickness, was found well displayed, and in the mottled clays at the base of the section shells of *Cyrena* were found sparsely distributed. The history of the excavation, and a list of the fauna having been given by the Director, the company proceeded to the higher ground to survey the physical aspects of the district. The flat delta-like tract of the Lower Thames Valley, the great "receiving drain" of the hydrographical basin, to use the words of Professor Phillips, with no containing sides comparable to those which, seen near Oxford, enclose the upper basin with great natural ramparts, was well seen from the spot. The company then proceeded to the chalk-pits at Grays, and spent an instructive hour examining the admirable sections (already described in these pages)* and scattered sarsen stones, and in obtaining the characteristic fossils of the Upper Chalk.

EXCURSION TO NORTHAMPTONSHIRE.

May 25th and 26th, 1874.

Director.—Samuel Sharp, Esq., F.S.A., F.G.S.

(*Report by* Wilfrid H. Hudleston, Esq., M.A., F.G.S.)

On meeting the party at Blisworth, Mr. Sharp at once proceeded to give an outline, illustrated by a diagram, of the formations in the district through which he proposed to act as conductor. In order to facilitate an understanding of the sections in the pits and quarries subsequently visited during the two days' excursion, the substance of his remarks explanatory of the geology of the district, is subjoined :—

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* "Proceedings of the Geologists' Association," vol. ii., p. 245.

"Proceeding upwards from the clays of the Upper Lias, we have a series of beds, which, as developed in the neighbourhood of Blisworth and Northampton, sometimes attain a total thickness of 80 feet. These consist in their lower portions of ironstones, often of great commercial value. The middle portions yield a red building stone, much used in, and very characteristic of, the county; whilst the upper portion consists of white sands, frequently containing a plant bed, and usually characterised by vertical plant markings. This latter is designated the 'Lower Estuarine Series,' the whole group being referred to the Inferior Oolite. Throughout the country about to be visited, extending from Blisworth in the S.W. to Stamford in the N.E., points upwards of 40 miles apart, the sequence above detailed holds true in the main for all portions of the district. When, however, we get above the Lower Estuarine bed, an important difference is observed to occur. At Blisworth and Northampton, reposing immediately, and perhaps unconformably, on the last mentioned bed, occurs a bed of blue clay, containing wood, plants, and bands of shells, some of which are said to be fresh-water forms (*Cyrena*, &c.). A ferruginous band occurs at the base. This clay has received the name of the "Upper Estuarine Series." It is succeeded by about 25 feet of a white, marly limestone, full of marine shells; above which, where the sequence is complete, is another clay, with abundance of *Ostrea subrugulosa*. These three beds, viz., the two clays and the intermediate limestone, are referred to the Great Oolite. Above all, there is frequently a capping of Boulder Clay. As we proceed north-eastwards, however, it is found that the beds called Upper and Lower Estuarine are no longer in contact, but that there is intercalated an Oolitic Limestone, which presently assumes considerable importance, and at Stamford, on the N.E. extremity of the district under consideration, attains a thickness of 75 feet."

The formation last referred to is called the Lincolnshire Limestone, but as no portion of it would be seen on the first day of the excursion, Mr. Sharp deferred making any further remarks, and gave the word to proceed to inspect the Blisworth Ironstone Diggings, about a mile and a quarter east of the station. A few men were at work in this quarry, which has a face, including the "baring" of about 30 feet. The base, or junction with the Upper Lias, was not actually observed, but the Lower Estuarine is seen at the top. The ironstone exists principally as a sesquioxide, and that portion selected by sifting is said to contain as much as 40 per cent of metallic iron. Few, if any, fossils were found by the party in this quarry, although Mr. Sharp has from time to time obtained many—all, or nearly all, as casts. A brief notice of this ironstone will be given after detailing the various quarries visited.

About a mile further on, a quarry in the Great Oolite Limestone, extracted chiefly for building, was visited. Here the party had an opportunity of observing about 18 feet of Boulder Clay, between which and the limestone there occurs about 18 inches of clay referred to the period of the Great Oolite. Several characteristic fossils were found in this quarry.

On his way back to the station and to Northampton, Mr. Sharp pointed out some buildings where the white limestone of the Great Oolite and the red stone of the Inferior Oolite have been used in alternate layers, with great effect of contrast.

The town of Northampton, at present containing a population of about 45,000 inhabitants, is very favourably situated upon an angle of high ground, sloping rapidly towards the river Nene on the south and towards the northern branch of the Nene on the west. The valleys of these streams are excavated in the Upper Lias. The bulk of the town, therefore, rests upon the sands of the Inferior Oolite, including under that grouping the ironstones, or their calcareous equivalents, and the Lower Estuarine Sands. This mass of rock, thus forming an escarpment of moderate slope towards the south and west, is further eaten away by denuding agents—on the north towards Kingsthorpe, and on the east just beyond Abington—to such an extent as to form a peninsula with a connecting isthmus not much over a quarter of a mile in width. Such a position would have great military advantages in the Middle Ages, and has probably had much to do with the historical importance of this ancient and celebrated town. It is a peninsula of Inferior Oolite, rising out of a sea of Lias. Yet the kings and generals of our early history, though ready to profit by this natural configuration of the ground, would have no more knowledge of the causes which had produced it than have the bulk of its inhabitants at the present day.

After luncheon, the party proceeded in carriages to carry out the programme of the excursion.

The afternoon was dull and threatening, with an occasional peal of thunder, but on the whole the clouds behaved well, and the drenching showers which fell only a few miles away were here not felt. The views afforded of the country, however, were comparatively limited, and the general features of its surface sculpture not so obvious as would have been the case in clearer weather. In the pits and quarries this was of no consequence, and the party soon found that Mr. Sharp was quite equal to the task that he, alone and unaided, had undertaken. Before doing anything geological, the party visited the "round church" of St. Sepulchre, supposed to have been built in the time of William the Conqueror. It has undergone many subsequent additions and subtractions, giving rise to much speculation amongst the learned in such matters. Mr. Sharp, Mr. Parker, and the clerical Members came to the front on this occasion. The first group of excavations visited all lay on the north side of the town. The lowest of these is the Kingsthorpe Brick-pit, where the ferruginous beds of the Northampton Sand are seen in contact with the Upper Lias, on which they repose. This is the only one of the numerous sections hereabouts where the actual contact was observed. There seems to be a rubbly broken bed about the junction, which may be a distinct passage-bed, or merely the disturbed upper surface of the Lias Clay mixing with the Northampton Sand above. Unless there is a fresh, vertical face at some distance below the actual surface of the soil, the indications are more or less obscure. The Nursery Pit is a continuation upwards of the Northampton Sand of the last pit. The beds here are ferruginous, but chiefly calcitic, sandstones, largely false-bedded, and sometimes Oolitic in texture. There are several vertical pipes to be observed—a phenomenon common enough in chalk-pits, but the peculiarity here is that the upper ferruginous beds are not attacked by the solvent, and consequently form a sort of bridge at the top of the pipes. No fossils were found in this quarry, though many hammers were brought to bear upon its layers of rock.

In the Kingsthorpe Sand-pit, the white sandy Lower Estuarine was observed, with its characteristic carbonaceous beds, from which a few species of Oolitic plants have occasionally been obtained. A considerable mass of compact red sandrock was here noticed; this runs into loose white sand both above and below. Continuing to ascend, the party, on the high grounds of Kingsthorpe (Moulton Park), again made the acquaintance of the Great Oolite Limestone, and those who were intent upon fossils found these marly cream-coloured rocks much better hunting ground than the sandy, irony, and calciferous beds which go to make up the Northampton Sand of the Inferior Oolite. *Rhynchonella concinna*, *Modiola imbricata*, *Myacites calceiformis*, and *Ostrea Sowerbyi*, were to be picked up in abundance. Besides these, specimens of *Clypeus Mülleri*, the characteristic *Pinna ampla*, *Myopsis dilatatus* (stunted specimen), *Isocardia tenera*, and several others, were obtained. Mr. Sharp pointed out also a hard semi-crystalline bed, crowded with *Alaria*, *Nerinæa*, *Astarte*, and other shells, but in such a matrix as to defy extraction without time and proper appliances.

Descending eastward, the Boughton Green Quarry was visited, where, as in the Nursery Pit previously noticed, the base of the Northampton Sand appears as a limestone more or less sandy, and not obviously fossiliferous. Indeed, up to this point not a fossil had been secured by any of the party from the Northampton Sand as evidence of its geological horizon. At Bass's Pit, however, nearer Northampton, a single specimen of the very characteristic *Rhynchonella cynocephala* was secured. Yet, by watching carefully, Mr. Sharp has obtained from these pits and elsewhere, a large series, in species more numerous than has been obtained from the much more fossiliferous Great Oolite above.

This completed the inspection of the north side of the town, through which the party now passed out towards the west, not, however, before making a pilgrimage *en passant* to the tomb of William Smith, "The Father of English Geology," who, whilst journeying to a meeting of the British Association, was in this town arrested by death, and buried in St. Peter's churchyard. His friends apparently have acted on the principle, "Where the tree falls there let it lie."

The Duston Quarries presented the most imposing section of the ironstone series of the "Northampton Sand" visited during the excursion, having 22 feet of ironstone alone. A few words, therefore, on the mineral condition and palæontology of these beds as developed in the neighbourhood generally may here find an appropriate place. Amongst the few fossils secured, were *Pecten personatus* and *Gervillia Hartmanni*; but, as in all other quarries of this stone, there were very few to be found. Mr. Sharp's collection, however, is so rich as to supply all that is required for reading the life history of the period to which these beds must be assigned. The majority of fossils from this place occur as casts. Judging from data thus supplied, there can be very little doubt that these beds belong to the Inferior Oolite, and to the lowest zone of that formation, as might indeed have been inferred from their resting immediately on the Upper Lias Clay. It is not quite clear whether the passage or " Opalinus-beds" should be included; but as *Ammonites Murchisonæ* occurs tolerably high up in the ironstone, that is at least probable, and many other facts such as the occurrence of *Rhynchonella cynocephala* point in the same direction. *Cardium Buckmanni*, *Pholadomya fidicula*, *Ceromya Bajociana*, *Isocardia cordata*, *Terebratula ovoides* (*T. trilineata* of Young and Bird), and numerous species of *Lima* and *Cucullæa*, peculiar to the Inferior Oolite, all tend to prove the true position of the ironstone; which indeed could never have been assigned to any other formation if the extensive series of fossils obtained since the working of these numerous quarries had been available at an earlier period. Their resemblance in many respects to the "Dogger," of North-east Yorkshire is most remarkable, as was some time ago pointed out to Mr. Sharp by Dr. Lycett. This latter fact suggests many reflections as to the original condition and subsequent metamorphism of these very singular beds. At present, the bulk of the mass consists of a yellow friable earth, partly sandy and partly Oolitic, seamed in all directions by hard bands, consisting chiefly of hydrous peroxide of iron. This, when sifted, constitutes a considerable portion of the commercial ore, and contains, perhaps, somewhat under 40 per cent of metallic iron. About 1,800 tons of it are raised weekly in the Duston Quarries. In some places there occurs a line of nodules of ferrous carbonate, and in the Duston Quarries a very striking feature is a thick band of greyish green iron-stone, low down in the series, which is rejected on account of the quantity of phosphoric acid which it contains. This is, for the most part, a carbonate of iron, with perhaps some silicate. Such is a very brief outline of the present condition of the beds. That this condition is the result of chemical changes, occurring at more that one period in the history of these rocks, the traces of so many organic remains prove most conclusively. And here the study of the contemporary (in a geological sense) ferruginous Oolites of Yorkshire may help us much. Taking the Dogger-beds at Blue Wyke, we find an arenaceous Oolite, in which there is hardly any lime. The ova there consist almost entirely of ferrous carbonate. It might be contended by those who are disposed to " strain at a gnat and swallow a camel" that this is a condition of original deposition. Fortunately, there is a fine series of the shells of Mollusca in these beds, which have undergone a similar change, and are almost wholly converted into spathic iron. The legitimate inference is that a salt of iron has replaced a salt of lime wherever the latter was present in the rock. Some are not satisfied with this explanation because they do not exactly see what has become of the lime. Such objectors might study the history of pseudomorphic action, as exhibited from the earliest times, with advantage. The source of such vast quantities of iron is a far more obscure question; but as the iron undoubtedly is there now, whether it arrived by deposition or replacement matters little. It must be borne in mind that most, if not all, of these Oolitic ironstones either in Yorkshire or Northamptonshire, are overlain by porous sandy beds, which frequently contain considerable traces of carbonaceous matter. This probably is but a vestige of what once existed in the peaty beds accompanying "estuarine" conditions. Layer after layer of micaceous sands, rich in iron, have been permeated by organic acids, the products of the decomposition of these vegetable masses, which attacking the mica and any such basic minerals which might be present, removed their more soluble constituents, and thus by perpetually exhausting the sands, left those bleached and partly coherent masses which so often overlie the ironstone beds. This is probably one source of the iron; as the solution, originating in the manner described above, and the ultimate decomposition of which would most probably result in the formation of carbonates, might possibly, in the presence of an excess of carbonic acid, decompose and replace any porous lime carbonates they might meet with in their descent. The presence of an impervious bed of clay at the base of such rocks would materially facilitate the operation, by keeping the original Oolite in a sort of bath, containing a solution of the replacing salt; though, of course, the hydrostatic pressure of the water would ultimately force the solution containing the intruded mineral to find an exit somewhere along the lines of least resistance; or it might be removed by simple diffusion in cases where the pressure was equal on all sides. The Yorkshire Oolitic ironstones remain carbonates still in many cases, probably because they have a great mass of rock above them. Those in Northamptonshire have undergone a second chemical change, principally from the action of oxygenated waters;

which have had the curious effect of producing a sort of centrifugal motion of the resulting oxide, which enables the owner t get rid of a good deal of foreign matter by the simple process o sifting. The whole subject as suggested by a contemplation o these beds is extremely interesting, and the above remarks must b deemed a mere nibble at so vast a question.

The last place visited was Watkin's Brick-pit, where the Uppe Estuarine clay is capped by a few feet of Great Oolite; close by i a pit of Lower Estuarine, separated from the Upper by a ferruginous band, not observed on this occasion.

Mr. Sharp then conducted the party to Dallington Hall, wher he and his family most hospitably entertained the Members. Th rest of the evening was spent in inspecting Mr. Sharp's magnificent collection of local fossils.

On the following day, an early start was made by train fo Stamford, about 40 miles distant. The line runs due north as fa as Market Harborough, through an undulating country, chiefly i the Upper Lias, yielding no good sections by the way. A sort o escarpment of the Northampton Sand flanks the route on the eas as far as Maidwell, where the first indications of the Lincolnshir Limestone put in an appearance. In this neighbourhood, th country is extremely fertile and beautiful; and seen on a fin spring morning like this, with its May-crowned hedge-rows, it lofty trees in their freshest green, and the great luxuriant pasture teeming with sheep and cattle, it presents a truly smiling pictur which may be deemed characteristic of this fair Midland count All this wealth of soil must be due to the mixing of the rich clay of the Upper Lias with the sands and calcareous matter derive from the destruction of the once overlying beds. From Marke Harborough to Stamford, the mean direction of the route wa N.E., and chiefly along the Welland valley, which is flanked on th S.E. by a fine escarpment capped by the Lincolnshire Limeston on the edge of which Cottingham, Rockingham Castle, and Gretto are commandingly perched.

Arrived at the Stamford Station, Mr. Sharp drew attention t the great dislocation which has occurred on the south side of th Welland valley, and which may be partly traced to the railwa cutting. The general effect of this dislocation is to divide th Inferior Oolite beds of St. Martin's from those at the top of th hill on the London road, a mass of Upper Lias being wedged i between them. This was also observed as the party ascended the hill towards Lord Exeter's ironstone quarries, which were visited, as also a quarry for road metal, where the party first made the acquaintance of the Lincolnshire Limestone, here a pale-coloured Oolite, not very fossiliferous. The ironstone section was poor compared with some the party had visited during the previous day, nor does it appear that there are any very valuable quarries in the "Northampton Sand" hereabouts. After luncheon at the George Hotel, once a celebrated coaching house, on the site of the ancient hostel of the Abbey of Croyland, the party drove through Stamford, which might be described as the stone town or city of churches, and up the hill on the north to the top of Stamford Field. From the level of the Welland to this plateau there is a rise of about 200ft. vertical, made up of the following beds in descending order:—

Great Oolite	Cornbrash—just a cap on the summit.	
	Great Oolite Clay—not exposed.	
	Great Oolite Limestone—base just seen.	
	Upper Estuarine Series—Torkington's Brick-pit.	
Inferior Oolite	Lincolnshire Limestone—many quarries.	
	Lower Estuarine Ferruginous Beds	Northampton Sand.
	Upper Lias Clay—a few feet.	

Torkington's Brick-pit presents an interesting section of about 25ft.—principally variegated clays, referred to the Great Oolite, and traced by the Geological Survey to the horizon of the Stonesfield Slate. It is known in Mr. Sharp's Memoir as the "Upper Estuarine," is of variable composition and thickness, frequently sandy, and is always found in this district underlying the Great Oolite Limestone. Several of the clay bands are pierced by vertical carbonaceous markings, and are also shelly; some fossils were picked up, but their condition was such as to render them very difficult of identification. *Modiola imbricata* and other bivalves were amongst them. The brackish-water genus *Cyrena* was found. The last two excavations visited within the Stamford area, north of the town, are quarries in the Lincolnshire Limestone. In Simpson's Quarry, from which is obtained some of the best building-stone in England, and the beds of which are geologically the same as those at Ketton, viz., the upper part of the Lincolnshire

Limestone, the blocks obtained are of great size, very uniform in their composition, consisting of a fine-grained Oolite, and ring like a bell when struck with the hammer. Above the Limestone, occur about 15ft. of the Upper Estuarine Clays, with a ferruginous band towards the base, as is usual. About the line of junction, there is often a thin band of white friable aluminous earth, somewhat of the nature of *Scarbroite*. In Tinkler's Quarry still lower beds of the Lincolnshire Limestone are obtained, including a Shale-bed, said to contain many shells, well preserved, but crushed. Below this is a hard blue-hearted limestone containing coral, *Nerinæa*, and many other fossils—the "Stamford Marble." Some fragments of coral were obtained by the party, but neither here nor in the other quarry were the spoils of the Lincolnshire Limestone of much consequence. One or two casts of *Natica Leckhamptonensis*, a specimen of *Lucina Wrightii*, and a doubtful *Trigonia*, were about all that came under the reporter's notice. These and adjoining quarries have, however, been watched for a number of years by careful palæontologists, and notably by Mr. Sharp, Mr. Bentley, and Professor Morris. It is in their collections, and especially in that of Mr. Sharp, that the evidence of the geological horizon of the Lincolnshire Limestone must be sought. For many years there was a general inclination to class these important beds (the Lincolnshire Limestone) with the Great Oolite; but the Geological Survey has ultimately decided to place them at the top of the Inferior Oolite formation, of which, throughout the county of Lincoln, they form by far the most important member. Notwithstanding their apparent poverty of fossils in the limestone quarries of Stamford, no less than 315 forms have been noted by Mr. Sharp from all parts, including, of course, the Collyweston Slates, a local group at the base of the series. One of the most remarkable features of this extensive fauna is the scarcity of Cephalopoda, especially of ammonites. *Ammonites terebratus*, Phill. (*A. macrocephalus*, Schlot., *A. Harveyi*, *Sow.*), marked as occurring, is a characteristic Cornbrash form. *A. Murchisonæ* and *A. subradiatus*, however, are the two other species quoted, and these represent very low zones of the Inferior Oolite.

The party now set their faces homewards, and, driving rapidly through Stamford, mounted the great plateau on the south side of the Welland, on which is situated the village of Collyweston, some four miles distant.

The "slate" is a sandy laminated limestone, very hard, and sometimes blue-hearted. Lithologically it is not unlike Stonesfield Slate. As the Geologists' Association had visited Stonesfield at Easter, those who attended both excursions had a good opportunity of comparing the two "slates." The state of the fossils (occurring chiefly as compressed casts) is exactly the same, and altogether there is a general external resemblance, which is very striking. Moreover, in each case, fossils are very abundant, but of a somewhat different *facies*. *Gervillia acuta* occurs plentifully in each, and there is likewise here a *Trigonia* not unlike *T. impressa* of Stonesfield, but beyond this point there is not much resemblance in their respective faunas. The party collected several species here, as *Hinnites velatus*, *Pinna cuneata*, *Avicula Braamburensis*, *Ceromya sp.*, *Cardiun Buckmanni*, *Cucullœa cancellata*, *Modiola Sowerbyana*, *Trigonia pullus*, *T. compta.*, and, most characteristic of all, *Pterocera Bentleyi*. Plants and some teeth and scales of fish occur, but the formation appears deficient in the remains of insects, reptiles, and mammals, which are the glory of the Stonesfield beds. After a delightful drive through Ketton, embellished, like so many of the towns and villages hereabouts, by a really noble church, and thence along the Stamford and Uppingham high road to Luffenham Station, the party took the rails once more, and arrived at Northampton at 7 p.m.

Before finally separating, the thanks of the excursion party were most heartily tendered to Mr. Sharp for his hospitality on the previous evening, and for the kindness and unwearied zeal which he had exhibited during two long and arduous days. Although it might have been a matter of regret that Mr. Sharp had been without assistance, yet had he been fully equal to the task thus imposed upon him alone. Mr. Sharp's claims as having contributed so materially to a proper understanding of Lower Oolite geology in the Midland Counties were pointed out. The Lower Oolitic region of the Cotteswolds, and of the S.W. generally, had long been the classic ground of geological study. There the formation is chiefly marine in its types, and in that region the Great Oolite group is well developed. For this reason, perhaps, when geologists sought to correlate the Lower Oolites of the rest of England with the typical districts, they were apt to refer too much to the Great Oolite. Hence, in Yorkshire, where the organic beds are few and fossils comparatively rare, or at least difficult to procure, Professor Phillips referred most of the series to the Great (or Bath) Oolite. At a subsequent period Professor Morris, in describing the sections on the Great Northern Railway, noted the important beds of limestone south of Grantham; and, although that eminent palæontologist was much struck with the important differences presented by the fauna of these beds to what obtains in the typical Great Oolite districts of the South-West of England, he seems, though with much hesitation, to have referred them to the Great Oolite. Subsequently, not being entirely satisfied, and knowing the great difficulty there must be in reconciling the phenomena of the North-Eastern and South-Western Oolitic areas, he ventured to predict that the key of the arrangement was to be sought in the district between Northampton and Stamford, the very district traversed by the excursion that day. It was shown that Mr. Sharp and Mr. Judd had succeeded in finding that key, which had unlocked the mystery that had puzzled geologists for so many years. This was no less than the laying down and defining the boundaries of that remarkable mass of limestone, which, commencing in a thin bed a few miles N.E. of Northampton, henceforth divided the two estuarine series, and at Stamford has already obtained a thickness of 75 feet. Mr. Sharp's collection, which Members had the privilege of inspecting on the previous evening, contained, as it were, the vouchers by which the age of this, the Lincolnshire Limestone, was to be known.

ORDINARY MEETING, JUNE 5TH, 1874.

HENRY WOODWARD, ESQ., F.R.S., F.G.S., &c., in the Chair.

The following Donations were announced:—

"Abstracts of Proceedings of the Geological Society of London;" from that Society.

"Journal of the Quekett Microscopical Club," April, 1874; from that Club.

"Proceedings of the Bristol Naturalists' Society;" from that Society.

"Proceedings of the Warwickshire Naturalists' and Archæologists' Field Club," 1873; from that Club.

"Proceedings of the Archæological and Natural History Society of Somersetshire;" from that Society.

The following were elected Members of the Association:—

Baron de la Taille des Essarts; Francis Robert Morrison, Esq.; and John T. Young, Esq.

The following Papers were read:—

1. ON THE LOWER GREENSAND AND GAULT OF FOLKESTONE.

By F. G. H. PRICE, ESQ., F.G.S., F.R.G.S., M.A.I.

It is my intention this evening to lay before you a short account of the Upper Neocomian and Gault of Folkestone, than which place I may remark, for the benefit of those who happen to be unacquainted with the district, there is no better locality on the south-east coast of England for the student of Cretaceous geology. If he makes that interesting old town his head quarters, he can take some most valuable and instructive rambles into the surrounding district, where fine and extended sections of all the various stages of the Cretaceous beds, from the Wealden, west of Hythe, to the Upper Chalk, near Dover, can be found.

THE LOWER GREENSAND.

The town of Folkestone is situated upon the Folkestone Beds of the Upper Neocomian.

In order to find the base of the Upper Neocomian series, we must go to Aldington Knowl, situated about five miles westward of Hythe, where the Atherfield Clay forms a long inland cliff extending to Hythe, but, as we are informed by Mr. Drew, F.G.S., in the "Memoirs of the Geological Survey," the beds of the Kentish Rag have slipped down and covered it up, consequently it is seldom seen. It is about 30 feet in thickness, and may be seen at very low water on the shore near Shorncliffe Battery. The Hythe Beds likewise make their first appearance at Aldington Knowl; the lower ground to the south being occupied by the Weald Clays; very fine sections of the Hythe Beds or Kentish Rag may be seen in the quarries at the back of the town of Hythe, from whence the Rag-stone is extracted largely for building. It is a limestone of a bluish colour, very hard, alternating with bands or beds of clayey sand, locally termed "Hassock," which is very fossiliferous. A lengthy list of fossils from these beds may be seen in the "Memoirs of the Geological Survey: On the Geology cure, Professor Phillips referred most of the series to the Great (or Bath) Oolite. At a subsequent period Professor Morris, in describing the sections on the Great Northern Railway, noted the important beds of limestone south of Grantham; and, although that eminent palæontologist was much struck with the important differences presented by the fauna of these beds to what obtains in the typical Great Oolite districts of the South-West of England, he seems, though with much hesitation, to have referred them to the Great Oolite. Subsequently, not being entirely satisfied, and knowing the great difficulty there must be in reconciling the phenomena of the North-Eastern and South-Western Oolitic areas, he ventured to predict that the key of the arrangement was to be sought in the district between Northampton and Stamford, the very district traversed by the excursion that day. It was shown that Mr. Sharp and Mr. Judd had succeeded in finding that key, which had unlocked the mystery that had puzzled geologists for so many years. This was no less than the laying down and defining the boundaries of that remarkable mass of limestone, which, commencing in a thin bed a few miles N.E. of Northampton, henceforth divided the two estuarine series, and at Stamford has already obtained a thickness of 75 feet. Mr. Sharp's collection, which Members had the privilege of inspecting on the previous evening, contained, as it were, the vouchers by which the age of this, the Lincolnshire Limestone, was to be known.

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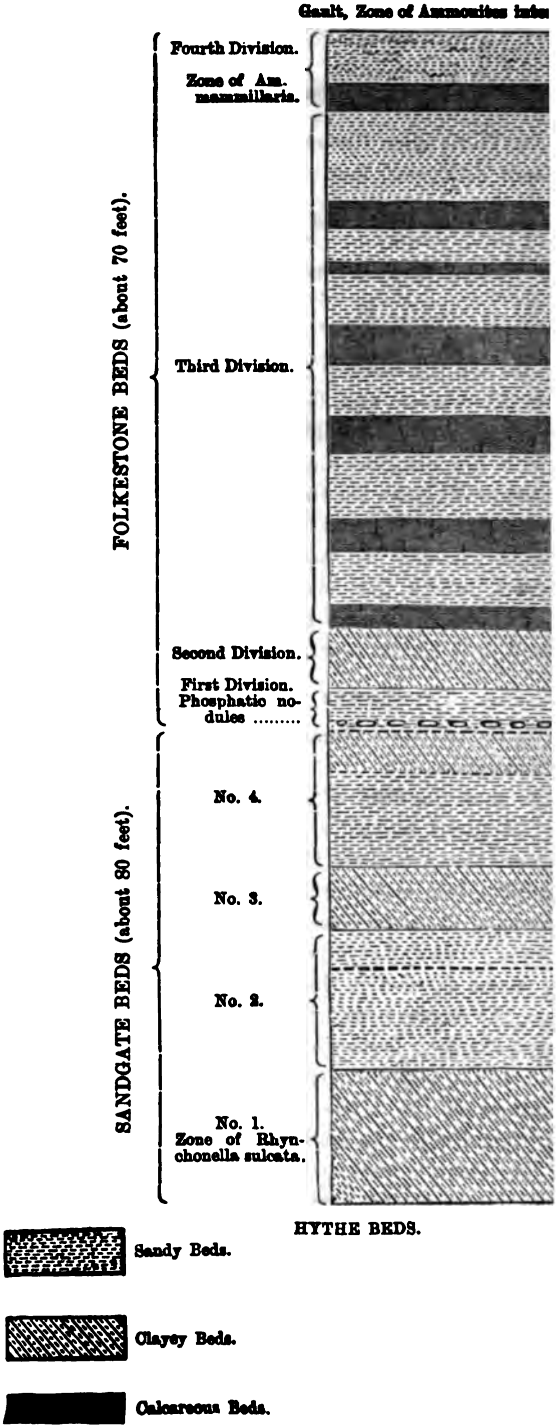
SECTION OF UPPER NEOCOMIAN BEDS, FOLK



of Folkestone, &c.," published with Sheet IV. of the Survey Maps. This deposit has a total thickness of 60 feet. I have not examined these beds lithologically, although I have visited the quarries several times, and have made a considerable collection of fossils from the various beds in that formation. I shall at present refrain from giving any list of the fossils collected until I shall have had time to work out the beds systematically.

The Hythe Beds are succeeded by the Sandgate Beds of the Upper Neocomian, which come on between Hythe and Shorncliffe; they dip N.N.E., until they finally disappear beneath the shore line a little eastwards of Folkestone Harbour.

The Sandgate Beds are the next in the series; they consist of dark sands and clayey sands supposed to attain a thickness of 80 feet. They rest upon the Hythe Beds of the same formation.

I have lately had an opportunity of visiting these beds in company with Mr. Jukes Browne, of Cambridge, and John Griffiths, with whom I examined them carefully at Folkestone, east of the harbour, and above the turnpike on the Sandgate Road. The result of our examination was, that we came to the conclusion that this division of the Upper Neocomian might be subdivided into four beds, to which I have affixed numbers.

No. 1.—The base bed is composed of black sands, which are well seen at spring tides on the shore a little eastward of Folkestone Harbour; at the top of this bed many nodules of iron pyrites occur, which frequently envelope specimens of *Rhynchonella sulcata.* The lower part of this bed I have not had an opportunity of examining. This bed is appropriately called the "Zone of *Rhynchonella sulcata,*" as large numbers are found in it. This zone is very fossiliferous. The following is a list of the fossils obtained from it:—

Wood.
Cones.
Rhynchonella sulcata (Park.).
Astarte sp.
Crassatella Cornueliana (D'Orb.).
Corbula sp.
Cucullæa glabra (Park.).
Cytherea sp. (very abundant.).
Exogyra sinuata (Sow.).
Gervillia anceps (Desh.).
Myacites plicata (Sow.).
Pectunculus sp.
Tellina sp.
Trigonia sp.
Avellana inflata ? (D'Orb.).
Dentalium sp.

No. 2. consists of dark green sands, passing up into yellowish-green sands. In the lower part of this bed, near Folkestone Harbour, a few fossils have been observed, among which the following may be noted :—

Coral.
Hemiaster sp.
Lima Cottaldina (D'Orb.)
Ostrea frons (Park.)

No. 3.—Black clayey sand—in parts very much resembling Gault.

No. 4.—The top bed of the series consists of yellowish-green sands, which are gradually succeeded by brownish clayey sands.

The Folkestone Beds of the Upper Neocomian form the high ground from above Hythe to Folkestone, where, gradually dipping N.N.E., they are lost beneath tide mark at Copt Point. From Sandgate to Copt Point they form an imposing cliff, often reaching an elevation of from 100 to 130ft., resting upon the Sandgate Beds. In the upper portion, The Third Division, false beddings may be seen in many places. At Baker's Gap, which is situated about half way between Folkestone Harbour and Copt Point, an interesting example of a slight anticlinal is seen, eastward of which the beds dip away at a greater angle. I have divided these beds into four lithological divisions, of which—

The First Division consists of a brown ferruginous sandstone of about one foot in thickness, holding a large quantity of phosphatic nodules, many of which have been much rolled, and have oysters adhering to them. At the extreme base of this bed large arenaceous nodules of brown sandstone occur, filled with casts of fossils, among which I have noted the following :—

Coral.
Serpula articulata (Sow.).
Corbula sp.
Cucullæa sp.
Lima sp.
Lucina sp.
Trigonia sp.
Avellana sp.
Janira Morrisii.
Ammonites, 2 sps.

This bed forms an excellent division between the Sandgate Beds and Folkestone Beds.

The Second Division is composed of a dark greenish clayey sandstone, reminding one very much of the "Hassocky" beds in the Hythe section of the series. It is about 2ft. in thickness, and is fossiliferous, the following having been found :—

Serpula articulata (Sow).
Rhynchonella sp.
Waldeimia pseudojurensis.
Avicula pectinata (Sow).
Ostrea frons (Park).
" sp.
Pecten orbicularis (Sow).
Janira Morrisii.

The Third Division consists of about 60ft. of seams of coarse calcareous sandstone, varying in thickness from 2ft. to a few inches, all of which are interstratified with layers of loose yellowish sand. It is from this bed that the stone is extracted for building which is generally known as Folkestone-stone. Large white tabular masses of branching sponge are met with upon these rocks. About 20ft. up in this bed the sand partakes of a black clayey character, but this is not constant along the whole horizon, but occurs only in patches here and there. It is apparently fossiliferous, as I met with *Pecten orbicularis* and a species of *Astarte* in it. Within 10ft. of the top of this bed a seam of chert occurs. In the top seam of rock I observed, remarkably large quantities of *Hemiaster*, partly covered over with a mass of the branching sponge before cited. Specimens of the latter my friend Mr. Jukes-Browne obtained with a view of submitting them for examination, to Mr. W. J. Sollas, of St. John's College, Cambridge, who, as is well known, has made a study of the sponges from the Upper Greensand of Cambridge, and I trust that within a short time the result of his investigation may be made known. In this bed the following fossils have been met with :—

- Polyzoa.
- Hemiaster sp.
- Spines of Micraster.
- Goniaster sp.
- Pseudodiadema.
- Serpula plexus (Sow.).
- Avicula pectinata (Sow.).
- Exogyra sinuata (Sow.).
- Gervillia anceps (Desh.).
- Janira atava (D'orb.).
- Pecten orbicularis (Sow.).
- Perna sp.
- Avellana sp.
- Waldheimia pseudo-jurensis.
- Ammonites sp.

The Fourth Division is the next and last bed I have to describe; it consists of an irregular seam of large rolled nodular masses of grit, composed of coarse grains of quartz, glauconite, jasper, lydian stone and phosphatic nodules. A considerable assemblage of fossils are obtained from this bed, which is termed the Zone of *Ammonites mammillaris*. Its fossil contents are all more or less in the condition of rolled phosphatic casts, a list of which I give below. The seam is succeeded by about 4ft. of loose yellowish sands, which seldom yield any organic remains; this bed is capped by the line of nodules of sulphuret of iron which form the base of the Gault. I roughly estimate the thickness of the whole formation at about 70ft. The following is a list of fossils from this division :—

Coral.
Holaster sp.
Goniaster sp.
Pseudodiadema sp.
Terebratula moutoniana.
Exogyra conica (Sow.).
„ sinuata (Sow.).
Inoceramus concentricus (Park.).
„ Salomoni (D'Orb.).
Pecten orbicularis (Sow.).
Janira atava (D'Orb.).
„ Morrisii.
Arca carinata (Sow.).
Astarte sp.
Cucullæa sp.
Lima Cottaldina (D'Orb.).
Lucina sp.
Cyprina sp.
Myacites plicata (Sow.).
Nucula pectinata (Sow.).
Thetis lævigata ? (Sow.).
Trigonia Fittoni (Desh.).
Pteroceras bicarinatum (D'Orb.).
Rostellaria sp.
Cerithium sp.
Avellana sp. ? (inflata ?)
Paludina sp.
Natica Gaultina (D'Orb.).
„ Clementina (D'Orb.).
Ammonites Bendantii (Brong.).
„ mammillaris (Schloth.).
„ sp.
„ sp.
Hamites rotundus
Turrilites sp.

THE GAULT.

The Junction bed, Bed I, or bottom bed of the Gault, first comes on, according to Mr. De Rance, in his paper on the Gault of Folkestone, at a point immediately over the turnpike on the Lower Sandgate Road, but I have failed to meet with it so far west on the coast section, but have examined this bed a little further inland at Cheriton, where some phosphatic diggings have been established. This junction bed may be traced along the East Cliff until it also disappears below the beach, dipping N.N.E., a little eastward of Copt Point.

The Gault must have been deposited in a subsiding area, and the sea of the time have been highly charged with sediment, caused by the denudation of the land, and by the action of the sea against the coast line. As all the fossils are so well preserved, they have doubtless been speedily covered by the sediment as it accumulated upon the floor of the Gault sea. When I say speedily, I would presume that the floor was composed of soft mud, and that as the animals fell upon it, they were not suffered to roll about and become comminuted, but were gradually covered up by the sediment. Had it been otherwise, the fossils would not be so well preserved, but would appear as rolled casts similar to those in the nodule beds.

I would suggest that these lines of nodules, mixed up as they are with rolled fossils, occurring so plentifully through the deposit, mark the floor of the sea during a period more or less vast, when great physical changes may have turned the direction of the currents and so borne away the sediment, which would otherwise have been deposited, in another direction. In this way, these lines of nodules, which are rarely more than one inch in thickness, may represent a period of time far greater than was required for the deposition of several feet of the clay. Thus, Bed VIII. with its several lines of nodules, would represent an enormously vast period, a period sufficiently long, as has been shewn, for over 100 species of Mollusca, forms plentiful in the Lower Gault, to become extinct.

The Gault is composed of stiff clays and marls, more or less of a bluish grey colour, which are nowhere seen to such perfection as at Copt Point, and in East Weir Bay, about one mile eastward from Folkestone Harbour. It there has a thickness of about 100ft.; and from it a large number of fossils have been obtained in a very fine state of preservation.

The Gault is divided into two divisions, the Upper and Lower, separated by a passage bed, and these are again sub-divided (as described in my paper " On the Gault of Folkestone," read before the Geological Society, on the 29th April last) into 11 well-marked zones, to which numbers have been attached for convenience, and provisional names assigned indicative of either the colour or fossil contents of the several bands.

Before proceeding to describe the various beds, it may not be out of place in me to urge upon all geologists the necessity of collecting fossils systematically, that is to say, of carefully noting the horizons in which they occur, and to avoid collecting them indiscriminately, without any knowledge of their locality or position in the particular deposit from whence they may be derived; as by so doing, says my friend Mr. Bedwell, in his valuable paper " On Ammonite zones in the Upper Chalk of Margate" read before this Association last year, we destroy land-marks which might prove invaluable to others. Much more than as yet been accomplished might be done for Geology and Palæontology, were this course generally adopted. Many species, more especially species of *Ammonites*, are peculiar to certain zones, constituting horizons; this, I may say without hesitation, has been fully proved. Thus by the knowledge of these zones, the geologist and palæontologist may ascertain and reckon the precise position of any fossil found.

The measurements given by the various beds set forth subsequently in this paper, were taken at Copt Point, and th "Pelter." I wish it to be understood that the divisions indicated in this paper are simply those of the Gault of Folkestone, the not having yet been proved to hold good over wide areas. I would be exceedingly difficult for anyone who had not thoroughl investigated the Gault *in situ*, to be able to make out the differen beds, as they lie on the shore in East Weir Bay. In consequenc of the water percolating through the Chalk above meeting wit the impervious floor of the Gault, a slide, as it were, is formed and the Chalk slips over the clayey beds into the sea. Thus, th Gault has been pressed out and faulted in great confusion, man of the beds being completely mixed together.

I took my measurements at Copt Point, commencing with th base of the Gault, or Junction-bed, Bed I., which rests upon th Folkestone Beds of the Upper Necomian, I shall therefore commence with that bed in giving my description of the Gault.

The lowest deposit is a line of nodules of iron pyrites, succeede by a band of dark greensand, containing two lines of phosphati nodules, in which *Ammonites interruptus* occurs frequently, fron which circumstance I propose to call this the Zone of *Ammonit interruptus*. Many other fossils, mostly in the form of rolle casts, occur in this bed; many of which are covered with smal crystals of selenite, which is never noticed on fossils from any o the other beds. Upon many of the broken pieces of *Ammonit interruptus* the following forms have been met with in good preservation, indicating that they were contemporaneous with th formation of the deposit:—

Plicatula pectinoides
Trochosmilia sulcata
Pecten quinquecostatus
Nucula sp.

The thickness of Bed I., from the top of the Upper Neocomian, to the line of nodules and crushed band of fossils, is 10ft 1in.

The next bed in ascending order is Bed II., which may, if w reckon the last as the Junction-bed, be considered the bottom o the Gault; it commences from the band of crushed fossils mixe with phosphatic nodules, and ends at a line where the cla becomes of a light fawn color, the thickness of which is 4ft. 2in The clay of this bed is of a very dark colour, almost black, an is remarkable for the deep lustrous colour of its fossil content arising from the large quantities of iron pyrites contained in the bed. Three inches upwards from the base, there occurs a band of selenite, which is peculiar to this horizon. One foot higher a line of nodules is met with; between these two bands *Aporrhais calcarata* is found, and nowhere else. The lower part of this bed is the position of *Nucula De Rancei*, likewise peculiar to that horizon, seldom found in proximity with *Aporrhais calcarata*. Nine species appear to be peculiar to this bed, one of which is a variety of *Ammonites auritus* possessed of long tubercles, in consequence of which I term this the Zone of *Ammonites auritus* var.

Bed III, the "Light-bed," so called from the light colour of its clay—or "Crab-bed," from the quantity of crustaceans found in it—exhibits a striking contrast to the dark colour of the preceding. It is measured up to a line of nodules and rolled fossils, upon many of which the shell is preserved and carapaces of crabs, *Palæocorystes Stokesii*, and *P. Broderipii.* In thickness it does not exceed 4ft. 6in. It may be well to mention that tabular masses of clay ironstone are found in this bed at irregular intervals, a piece of which I submitted to my friend Mr. W. H. Huddleston, our Honorary Secretary who kindly analysed it for me, and found that it contained as much as 30 to 40 per cent. of metallic iron.

Bed IV., is a very narrow band, being only 4in. in thickness; it is measured from the line of nodules before named, up to a line of phosphatic nodules and rolled casts of fossils. In these nodules a diminutive species of *Hoploparia* is found, which is never met with elsewhere. In colour the clay is somewhat darker than that of the preceding bed, and not mottled as is that of Bed V. Four species appear to be peculiar to the zone, these are: *Natica obliqua*, (described by me in my paper "On the Gault of Folkestone," read before the Geological Society); *Fusus Gaultinus*, an ammonite with very long spines, which may be considered a variety of *Ammonites tuberculatus*, and *Ammonites De La Ruei*, a form belonging to the *Cristati* group. I may here remark that from my experience I have noticed that the lower division is characterized by the presence of the *Dentati* and *Tuberculati* group of *Ammonites*, which are deeply grooved, whereas the upper division is remarkable for the presence of the *Cristati* group of *Ammonites*, thus, the meeting with *Am. De La Ruei* in this bed, and *Am. Roissyanus* in Bed No. 1, both belonging to the *Cristati* group, form the exceptions to the rule, the only exception in the Upper

Gault being a variety of *Ammonites lautus*. This bed may be called the " Zone of *Ammonites De La Ruei*."

Bed V.—This is called the " Coral bed, " from the quantity of those beautiful little fossils it contains. The clay is of a dark colour, spotted to within a few inches of the top with light fawn-coloured markings. The bed is only 1ft. 6in. in thickness, being measured from the line of nodules containing rolled casts of fossils, up to a line where the clay becomes more strongly marked. Eight species are peculiar to this horizon, which I have named the " Zone of *Ammonites lautus*."

Bed VI., called the " Mottle-bed," from the lightish-coloured markings which throughout pervade the clays of this bed, is of small vertical thickness, probably not more than one foot. It is measured from the top of the preceding zone to a hard seam. The clay is darker in colour than that of Bed V. It may be considered the " Zone of the *Ammonites denarius*." There are six species that I have met with peculiar to it, which are :—

Homolopsis Edwardsii (Bell)
Necrocarcinus Bechei (Deslong.)
Fusus elegans (D'Orb.)
Scalaria gastyna (D'Orb.)
Turrilites Hugardianus (D'Orb.) and a small variety of Ammonites cornutus (Pictet)

Bed VII. usually styled the " Dark-bed," is the top of the Lower Gault, and is measured from the hard seam forming the limit of Bed VI., up to the first line of nodules in Bed VIII. It has a thickness of 6ft. 2in., and the clays are of a very dark colour, though not so dark as those of Bed II. It is highly fossiliferous, as many as 64 species have been obtained from it. The class Gasteropoda appears to have reached its maximum of development in this zone. There are several species peculiar to it. *Ammonites auritus* occurs in large quantities, from which circumstance I propose to call it the " Zone of *Ammonites auritus*." *Buccinum Gaultinum* first appears in the middle of this bed, and is continued into the Nodule-bed as above. The following are only found in this bed :—

Nucula albensis (D'Orb.)
Aporrhais Parkinsoni (Sow.)
Fusus indecisus (D'Orb.)
Cerithium tectum (D'Orb.)

Bed VIII., usually called the " Nodule bed" from the large number of phosphatic nodules it contains, is measured from the first line of nodules forming the top of Bed VII. to a second line of nodules, and has a thickness of 10in. This bed is a true junction or passage bed, dividing the Upper from the Lower Gault. It holds many species belonging to both divisions, and marks the total extinction of many of the Lower Gault forms, no less than the introduction of others which took their place. In my note on the last bed, Bed VII., I mentioned the fact of its being peculiarly fruitful in Gasteropoda. Now it may be worth recording that few species of this Class pass into Bed VIII. at all, those which do being generally in the form of rolled casts much encrusted with phosphate. Out of 47 species obtained from the Lower division only 10 of them pass into this passage-bed; it likewise contains three species peculiar to it. In the Upper Gault 11 species of Gasteropoda have been met with, six of which are continued from the Lower division, the remaining five being peculiar to the Upper. This appears to point to the fact that the conditions which obtained during the deposition of the Upper Gault were unfavourable to the continuance of the more delicate forms of life, or, if on the other hand they were continued, that the chemical constituents of the sediments deposited during the process of the formation of these marls were unfavourable to the preservation of specimens.

During the period I have paid attention to this formation, I have collected as many as 247 speciesof all Classes from the Gault of Folkestone, that I have been able to assign to particular genera; but there are fully 25 other forms that have been met with, which up to the present time I have been unable to determine. Out of the above number 124 forms become extinct in Bed VIII.; and 46 forms are continued into the Upper Gault. In addition to this bed containing the limit fauna, it possesses 20 species peculiar to itself. As many as 57 new forms, none of which have been observed in the Lower Gault, make their first appearance in Bed VIII., or in a higher zone, thus constituting the number of the fauna hitherto observed as being peculiar to the Upper beds. Ammonites belonging to the various groups are of frequent occurrence in this bed; the most characteristic species is *Ammonites cristatus*, from which circumstance I propose to name this bed the "Zone of *Ammonites cristatus*."

Among the Ammonites peculiar to this zone the following may be mentioned as occurring:—

Ammonites Beudantii (Brong.)
„ Brongniartianus (Pictet.)
„ Iterianus (D'Orb.)
Ammonites Selliguinus (Brong.)
„ splendens? a grooved variety
„ tuberculatus, a variety.

Cucullæa glabra (Park.), *Cyprina quadrata* (D'Orb.), and *Scalaria Gaultina* (D'Orb.), are especially characteristic of the bed.

Bed IX. forms the base of the Upper Gault; the geologist will at all times be able to indicate his position by the large quantities of crushed forms of *Inoceramus sulcatus* contained in this bed. It is true that this well-marked form occurs in the Zone of *Ammonites cristatus*, but in no great numbers. It is mentioned by Mr. De Rance, in his valuable paper "On the Albian, or Gault of Folkestone," that this shell first occurs in the Lower Neocomian clay of Hythe; is not again found in the Aptian series, but reappears in the Zone of *Ammonites interruptus;* a single specimen only, however, has been found by Mr. Etheridge. Had that specimen been recorded as being met with in that zone by anyone else than our distinguished Vice-President, I should have doubted the circumstance, as I have repeatedly found this fossil at Copt Point, mingled with the fragments of *Ammonites interruptus*, but have always considered it to have been knocked out of the Upper Gault, and rolled into this place probably by the action of the waves. I should much like to prove the matter by finding one myself *in situ*. This bed is measured from the line of nodules at the top of the last described up to a line of nodules, containing vast quantities of crushed forms of *Inoceramus sulcatus*. The thickness of this bed is 9 feet 4½ inches. *Inoceramus sulcatus*, first met with in the Zone of *Ammonites cristatus*, does not pass out of Bed IX. The Gault of this zone is full of them; one can hardly dig up a foot of the marly clay without seeing the shining casts of dozens of them. In this same bed is found an intermediate form between this and *Inoceramus concentricus.* This fossil was named *Inoceramus subsulcatus* by the Rev. T. Wiltshire. Griffiths, the well-known collector of Gault fossils at Folkestone, styles this zone the "half and half bed," in consequence of the frequency of occurrence of this hybrid form Almost as numerous as *Inoceramus sulcatus* is the *Ammonites varicosus*, which first appears in Bed VIII., and is sometimes met with in Bed X.; but it attains its maximum of development in the bed now under consideration, in consequence of which I have called this the "Zone of *Ammonites varicosus*." A variety of the well known *Ammonites lautus* occurs in this zone, forming another exception to the rule of the Upper Gault being restricted to the *Cristati* group. It ranges from the Nodule-bed, Bed VIII., up to a hard seam near the top of the Zone of

Ammonites varicosus, above which it has never been observed. This is the only exception known to me of an Ammonite of the *Dentati* group being met with in the Upper Gault. Below this hard seam, *Ammonites rostratus* (Sow.), the *Ammonites inflatus* of D'Orbigny, makes its first appearance, and extends up to the base of the Upper Greensand. From this bed specimens of *Pinites hexagonus* (Carruthers) have been obtained.

In the discussion which followed my paper read before the Geological Society, Mr. Carruthers referred to the discovery by Mr. Gardner and myself of cones of two species of *Sequoia*, "and, associated with these, some species of *Pinus*, two of which were to be referred to a group of that genus at present found associated with two existing species of *Sequoia* on the mountains of western North America. These sequoiæ from the Gault are the oldest known representatives of the genus; and it is remarkable that they should be thus early associated with species of the same group of pines which is now represented only in the same country where the sequoiæ also grow." It may be worth remarking that *Pholadomya fabrina* (D'Orb.) is only met with *in situ* in this bed; it, however, appears in Bed VIII. in the form of rolled casts.

Bed X. commences at the crushed band of *Inoceramus sulcatus* and extends to a line of phosphatic nodules, containing specimens of *Pecten Raulinianus* (D'Orb.), which line occurs at 5 feet 1 inch above the limit of the last zone.

The Gault of this bed partakes more of the character of marl than of the preceding beds; it is hard, and of a cold, pale grey colour, and poor in organic remains, which fact may possibly be due to the large percentage of carbonate of lime the Upper Gault has been proved to contain; to which cause we may certainly ascribe the disappearance of the lustrous shells from the fossils. A line of phosphatic nodules occurs at 2 feet 8 inches above Bed IX., containing large quantities of *Plicatula pectinoides*, which are there met with in fair condition. Between these two lines of phosphatic nodules, giving a space of 2 feet 5 inches, the Gault is mottled, and masses of *Pentacrinus Fittoni* occur. This is remarkable, as in all other parts of the deposit it is only met with in pieces. *Cidaris Gaultina* is likewise peculiar to this circumscribed position. These lines of nodules produce many fragments of chelonian and fish bones, likewise teeth of *Hybodus* and *Otodus appendiculatus*. The most remarkable forms ever obtained from this bed are some circular and more or less compressed bodies, possessing the texture of egg shells. To the best of my belief only three of these fossils have ever been discovered, two of which are in the cabinet of Mr. J. S. Gardner, F.G.S., and one in my own collection. This latter I showed to Mr. J. W. Hulke, F.G.S., who considered it as probably quite new, and that in the coarse pitting of the shell it resembled that of *Crocodilus biporcatus* (?). The most characteristic fossil in this bed is *Kingæna lima* (Defrance). From the frequency of its recurrence, my friend Mr. De Rance named this zone after it, in his paper "On the Albian, or Gault of Folkestone," and I readily adopt the same conclusion arrived at by him, and propose that this bed should be styled the Zone of *Kingena lima*. The following fossils are peculiar to this zone :—

Goniaster sp.
Kingena lima (Defrance)
Hinnites sp.
Astarte sp.
Aporrhais maxima (Price)
Crocodilus biporcatus (?)

Bed XI.—This bed, equal to more than half of the whole formation in thickness, consists of a cold, pale grey marl, traversed by a series of dark partings, the smooth portions between which are smeared over with a coating of oxide of iron. My friend Mr. W. H. Hudleston, F.G.S., was kind enough to analyse a piece of gault from this bed, and found that it was a marl, with particles in a minute state of subdivision, the bulk of the mass being a mixture of chalk and clay, containing a few extremely small quartz grains, and after treatment with acid one or two translucent greenish grains were observed; also fragments of pyrites and small crystals. This sample, which was dried at 100 c., was found to contain 26·45 of carbonate of lime, being nearly 18 per cent. more than is contained in Bed II. This bed yields 2.55 per cent. of metallic iron. In the upper portion of the bed, at a distance of 35 feet 6 inches from the base of it, a seam of dark green sand obtains, having a thickness of 3 feet 3 inches. This is called by Griffiths the "Middle Greensand." The marly clay above this green sand is for the first few feet much intermixed with green grains, after which it assumes the same homogeneous marly character as the lower portion of the bed. There is 17 feet 6 inches of Gault above the green sand seam. Immediately below this seam a small form of *Ptychoceras* occurs, always in iron pyrites, which is not met with in any other part of the deposit. I have also found the *Hylospongia* of Sollas there.

Several lines of nodules occur in the band of green sand, chiefly composed of pyriform sponges. The following Fossils are likewise met with :—

Trochocyathus conulus (Edw. & H.)
Pollicipes sp.
Avicula gryphæoides (Sow.)
Pecten orbicularis (Sow.)
Plicatula pectinoides (Sow.)
„ sigillum (Sow.)

Aporrhais Orbignyana (Pictel et Roux)
Solarium ornatum (Sow.)
Ammonites Goodhallii (Sow.)
Belemnites ultimus (D'Orb.)
Drepanephorus canaliculatus (Eg.)
Icthyosaurus campylodon (Carter)

Immediately above this seam *Ammonites varians*, a form so characteristic of the Chalk Marl, is first met with. *Inoceramus Crispii*, and *Ammonites rostratus*, attain very large dimensions in this bed, the latter being frequently met with measuring over 12 inches in diameter. This zone may be termed the " Zone of *Ammonites rostratus.*

Before concluding this paper, it may be of value to name the following forms as being characteristic of the whole formation, they having continued in every zone throughout the period occupied by the deposition of these clays :—

Plicatula pectinoides (Sow.)
Inoceramus concentricus (Park.)
Nucula ovata (Mantell.)
„ pectinata (Sow.)

Aporrhais Orbignyana (Pictet et Roux).
Natica Gaultina (D'Orb.)
Dentalium decussatum (Sow.)
Nautilus clementinus (D'Orb.)

The class Brachiopoda has been found to be confined to Upper Gault entirely, *Terebratula biplicata* first appearing in a rolled form in the Zone of *Ammonites cristatus*, and continuing upwards through the several beds; it is, however, most abundant in the Zones of *Ammonites varicosus* and *Kingena lima.*

It ever appears to me to be remarkable that *Rhynchonella* has not been met with in the Gault, and I cannot directly ascertain where any specimens of that genus have been met with in the Folkestone Beds of the Upper Neocomian. Only one species appears to have been described from the Red Chalk of Hunstanton, and that is the *Rhynchonella sulcata* (Park.), which occurs in large quantities in the Sandgate Beds of the Upper Neocomian, near Folkestone Harbour, both embedded in the sands and in masses agglutinated together with iron pyrites, this particular zone being No. 1., before cited. Now no species of this genus is met with in this area from this zone upwards till we reach the Chalk Marl, where it again obtains, missing alike the Gault and Upper Greensand. It would be interesting to ascertain what were the conditions at that period prevalent in these seas which caused this interesting genus to migrate to some outer area.

2. ON A COLLECTION OF FOSSILS FROM THE UPPER GREENSAND OF MORDEN, CAMBRIDGESHIRE.

By H. GEORGE FORDHAM, ESQ., F.G.S.

This collection is from the so-called "Coprolite" or phosphatic nodule beds of the Upper Greensand or Chloritic Marl, at two localities near Ashwell and Morden, on the borders of Hertfordshire and Cambridgeshire, where pits for the extraction of the nodules have been worked for some years.

Mr. Bonney, in a paper read before this Association two years ago,* has so clearly detailed the general configuration of the country, the position of the bed and mode of working for the nodules, near Cambridge, and his description applies so well to this part of the country, that it is not necessary for me to touch on these points.

The bed is from 18 inches to 3½ feet in thickness, and varies considerably in the proportion of nodules. It graduates into the Chalk Marl above; the glauconitic grains extending higher than the nodules, and the nodules being more abundant in the lower part of the bed. The origin and cause of formation of phosphatic deposits at the period of the Gault and Greensands is one which is of great interest to the geologist, and is one of the important geological problems which have yet to be solved. The great number of localities in Europe at which phosphatic deposits of this period have been found would incline one to believe that the sea at that time was more highly charged, in the European area at least, with phosphate of lime than it is at present. I am inclined to think that the more probable solution of this question is to account for the excess by the presence of the remains of fish and other animals in larger quantities than now exist in our seas.

The occurrence of certain pebbles and boulders of foreign rocks, sometimes rounded by attrition, has been ascribed by Messrs. W. J. Sollas and A. J. Jukes-Brown in an interesting paper, (Quart.

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* "Proceedings of the Geologists' Association," vol. iii., p. 1.

Journ. Geol. Soc., Vol. xxix., p. 11) to the transporting power of ice; and having regard to the discovery of large boulders in the Chalk, and of a quartz pebble in the Gault at Folkestone, this appears to be the most likely method of accounting for their position in this bed. I have been so fortunate as to have obtained two boulders which, in masses of attached phosphate of lime and shells, bear seals of their genuineness; and also some smaller pebbles, which, although I picked them myself from a heap of the unwashed marl, *may* have been derived from the gravel which sometimes becomes mixed with it. I am inclined to believe, however, that some of them belong to the Greensand.

The position of the Greensand in the pits made to obtain the nodules, viz., at the bottom, makes it almost impossible to collect from the bed *in situ*, and as the marl when thrown up is generally, immediately removed to the washing mill, almost the only way to obtain fossils is to search the heaps of washed nodules; this mode of collecting is in many respects unsatisfactory, as the fragile shells are broken and destroyed in the washing mill, and all the specimens suffer attrition. It must also be borne in mind that the proportionate quantity of fossils must be much greater when compared with the heaps of nodules (which themselves form perhaps 1-20th or less of the whole deposit), than when compared with the entire mass of the bed itself. I have had, however, on one occasion, when some of the marl was dug up and left for some months exposed to the atmosphere, an opportunity of obtaining some of the more fragile specimens, and of getting more accurate ideas of the comparative rarity of the different species.

LIST OF FOSSILS FROM THE UPPER GREENSAND, MORDEN AND ASHWELL.

REPTILIA—
- **Ichthyosaurus campylodon—**
  - Teeth, vertebræ, and fragments of other bones. Not very common.
- **Polyptychodon—**
  - Teeth. Rare.
- **Plesiosaurus—**
  - Vertebræ. Rare.

PISCES—
- **Otodus appendiculatus—**
  - Teeth. Common.
  - Vertebræ. Rather rare.

PISCES—
- **Saurocephalus lanciformis—**
  - Teeth. Rare.
- **Edaphodon—**
  - Fragments. Rare.
- **Gyrodus—**
  - Palatal teeth. Very rare.
- **Lamna—**
  - Teeth. Common.

- MOLLUSCA—
  - Cephalopoda—
    - Ammonites rostratus. Rather common
    - A. cratus. Rather common.
    - A. cælonotus. Rather common.
    - A. pachys. Rare.
    - Hamites. Rare.
    - Baculites. Rare.
    - Belemnites minimus. Common.
    - B. ultimus. Rather common.
  - Gasteropoda—
    - Pleurotomaria (? rodani, D'Orb.) Rather common.
    - P. Brongniartianum. Rare.
    - P. semiconcava. Very rare.
    - P. Gibbsii (?) Very rare.
    - P. Rouxii (?) D'Orb. Rare.
    - Solarium ornatum. Rare.
    - Dentalium ellipticum. Rather common.
  - Lamellibranchiata—
    - Ostrea vesicularis, Lam. Very common.
    - O. frons. Common.
    - O. macroptera. Very rare.
    - Exogyra sp. Very rare.
    - Plicatula sigillina. Very common.
    - P. pectinoides var. inflata, Sow. Common.
    - Spondylus truncatus. Rather rare.
    - Nucula simplex. Very rare.
    - Inoceramus. Rare.
    - Radiolites Mortoni. Rare.
- MOLLUSCA.
  - Lamellibranchiata—
    - Avicula gryphæoides. Very common.
    - Pecten quinque-costatus. Very rare.
- MOLLUSCOIDA—
  - Brachiopoda—
    - Terebratula biplicata. Very common.
    - T. obtusa. Rare.
    - T. semiglobosa (?) Rather rare.
    - T. ovata. Rather rare.
    - Terebratulina gracilis. Common.
    - Terebratella (Kingena) lima. Rare.
    - Rhynchonella sulcata. Rare.
    - R. lineolata var. Carteri. Very rare.
- CRUSTACEA—
  - Hoploparia—
    - Fragments. Very rare.
- ANNELIDA—
  - Serpula. Rather common.
- ECHINODERMATA—
  - Spines. Rather rare.
- CŒLENTERATA—
  - Smilotrochus elongatus (Duncan). Rare.
- PROTOZOA—
  - Ventriculites.
  - Chenendopora. Rather common.
  - Parkeria. Very rare.
- DRIFT WOOD, perforated.

Taking this collection as affording a fair representation of the fauna of the Upper Greensand in this locality, and comparing it with the collection in the Woodwardian Museum at Cambridge, the almost entire absence of Echini (except the spines), the great rarity of Crustacea, the general absence of di-myarian Lamellibranchiata, Gasteropoda (except *Pleurotomaria* and *Solarium*, *Dentalium*), and *Nautilus*, and the commonness of *Belemnites*, are perhaps worthy of note. The specimens are also much less perfect than at Cambridge, and are generally very badly preserved.

EXCURSION TO TILBURSTOW AND NUTFIELD,

JUNE 13TH, 1874.

Director: J. LOGAN LOBLEY, ESQ., F.G.S.

No portion of the route traversed by Members during this excursion, including the line of railway from London to Caterham, was found to be wanting in geological interest. After crossing the Thames Valley deposits of Post Pliocene age and the Lower Eocene of the southern portion of the London Tertiary Basin, the railway enters a cutting exposing, south of Croydon, the Woolwich and Reading Series, and the Thanet Sands reposing on the Chalk, thus showing the southern edge of the London Basin. The Purley Beds and the Upper and Lower Kenley Beds of the Upper Chalk, of Mr. Caleb Evans, are passed, and the fine typical Chalk valley of Kenley, with Riddlesdown bounding one side, is traversed; the White Leaf Beds, and the Upper Marden Park Beds of the Lower Chalk then form the country until Caterham is reached. Here the Members alighted on Lower Chalk, a good exposure of which was seen close to the railway station.

The road through Godstone to Tilburstow Hill was taken, and after a pleasant walk of a mile from Caterham the "Firestone" quarries of Godstone were reached. These extensive workings in the Upper Greensand, here represented by the soft calcareo-siliceous rock with green grains, for ages known by the name of firestone, were entered by the Members, a few of whom penetrated for some distance into the galleries which are excavated for long distances under ground. The firestone, though soft and easily worked, stands extreme heat, and is therefore valuable for the sides and bottoms of furnaces, baker's ovens, and the like. The Upper Greensand is here of no great thickness, and the Gault gives, at a little distance, evidence of its presence by the darker green of the vegetation growing on its heavy clayey soils. The valley through which the road runs now widens, with Gault forming the bottom, and the pretty village of Godstone with its pool, indicative of argillaceous beds, is soon reached and passed through, when Tilburstow Hill, the southern boundary of the Godstone valley, appears immediately in front.

Before gaining the summit of the hill an exposition was given of the physiography of the country seen to the north, embracing the valley between the North Downs and the Lower Greensand hills which skirt the Weald, and through which a portion of the head waters of the Medway flow in a small brook called the Broad Mead Water. Ascending to the summit of Tilburstow the Members stood on one of the most commanding of the hills on the north side of the great Wealden valley, and turning from the beautiful Upper Cretaceous valley, which had just been crossed, they surveyed the still more beautiful and far more extensive Valley of the Weald which stretched far as the eye could reach to the south, to the east, and to the west. In the centre of this great "valley of elevation" the "Forest ridge" rising above the surrounding country, was conspicuously observable, and some of the hills at the western extremity of the Weald could be dimly descried through the distant summer haze which softened the further outlines of the splendid landscape.

Leaving with reluctance the hill top the party descended to the Nutfield Road, which traverses the hill from east to west, and proceeding westward several quarries in the Lower Greensand were met with, in which the useful calcareous building stone, the Kentish Rag, was found interbedded with bands of clay, and associated with a large amount of chert. After passing through the villages of Bletchingly and Nutfield the fullers-earth workings were visited. Fullers-earth has long been obtained from the Lower Greensand of Nutfield, and is found to be superior in quality to the similar argillaceous earth which gives name to the beds between the Inferior and Great Oolites. Associated with the earth, crystals of barytes, often with cubes of iron pyrites attached, are found in considerable quantity. Some time was spent in inspecting the workings and examining the beds, after which a rapid descent from the high ground of Nutfield brought the Members to Red Hill Station, from which the train to London was taken.

EXCURSION TO HAMPSTEAD, JUNE 22ND, 1874.

Director: CALEB EVANS, ESQ., F.G.S.

(*Report by Mr. Evans.*)

The party assembled about half-past six at the flag-staff near Jack Straw's Castle, at which spot the Director explained, by means of diagrams, the geology of the district within view.

The greater portion of the district is occupied by the London Clay, which at Hampstead, Highgate, and Harrow passes gradually into a sandy clay abounding with well preserved fossils, and then into the Lower Bagshot Sands, while at Mill Hill, Totteridge, Barnet, and Stanmore Heath the London Clay is capped by "Pebble-gravel," traces of which are also seen on Hampstead Heath.

From North End the position of the Glacial beds of Hendon and Finchley were pointed out, and the two periods of denudation (the one pre- and the other post-Glacial) were explained.

The party returning by the Vale of Health followed the junction of the Bagshot Sands and London Clay from that spot to the spring in Well Walk, and concluded the evening by inspecting Mr. C. Evans' collection of Tertiary fossils at his residence.

EXCURSION TO ST. MARY'S CRAY, WELL HILL, AND SHOREHAM, KENT.

SATURDAY, JUNE 26TH, 1874.

Director:—JOSEPH PRESTWICH, ESQ., F.R.S., F.G.S., &c.

(*Report by* HENRY WALKER, Esq., F.G.S.)

On arriving at St. Mary's Cray, and being joined by Professor McKenny Hughes, the party inspected the cutting at the St. Mary's Cray Station, which exposes lower pebbly beds of the Woolwich and Reading Series and Thanet Sands. The valley deposits, close to the Gas Works, were then visited. These were found to consist of ten or twelve feet of fine loamy brick-earth, with land shells, and a little gravel; the whole having a "rain-wash" aspect. The Chalk was seen below. Professor Hughes gave an admirable field lecture on the physical history of the landscape of which this valley is one of the features, and then a start was made for Skid Hill, where Mr. Prestwich, F.R.S., was to meet the Members, and act as conductor for the day. The walk from St. Mary's Cray to Skid Hill was a delightful one, through Kentish lanes, rich in the wild flowers of June, with great landscapes anon bursting into view under one of Constable's skies. Kevington, East Hall, and Skid Hill, the last named signalised by two grand trees of Portugal laurel (*Cerasus Lusitanica*) loaded with racemes of fragrant white flowers, were successively reached.

Mr. Prestwich, who had walked from Shoreham for the purpose, now came forward as geological guide. The physical and topographical features immediately westward were first explained, Keston, Knockholt Beeches, and the long dry valley of the upper Cray being notable objects in the view. Skid Hill itself (capped with gravel) is but a portion of the interesting outlier of Thanet Sands and Woolwich Clay which at Well Hill—a mile further along the same elevation—has a still larger deposit of gravel of great age and singular interest. Indeed, Well Hill was the central point of interest for the day. Have we here, in Kent, a true Glacial gravel? At length the higher ground, more than 600 feet above Ordnance Datum, was reached, and the Well Hill gravel sections confronted the visitors. Here above the Thanet Sands and Woolwich Beds were large rolled flints, highly fossiliferous, in a reddish sandy matrix, unstratified. A closer search, at the suggestion of Mr. Prestwich, discovered fragments of chert and ragstone. These Mr. Prestwich referred to the Lower Greensand beds of the Sevenoaks Range, some six miles further south, and separated from Well Hill by the deep and broad valley of Holmesdale. The Well Hill gravel, according to Mr. Prestwich, is a solitary patch of marine gravel, of Glacial age, which once stretched over Kent, and is altogether an unique geological memento in the county. Illustrated with pencil and paper, and explained in a painstaking manner by Mr. Prestwich, the subject gave a wonderful charm to the well-marked panoramic landscape which is seen from Well Hill. Before leaving the spot the following orchids were gathered on the damp parts of the heath about Well Hill—*Orchis maculata*, *Habenaria bifolia*, and *Listera ovata*, and close at hand under the trees *Ophrys muscifera.*

On leaving Well Hill, the excursionists felt they had seen the great sight of the day. The following objects, to which Mr. Prestwich called attention on the arrival at Shoreham may also be mentioned:—Some notable sand-pipes in the Chalk, by the side of the high road to Sevenoaks, between the eighteenth and nineteenth milestones, a very fossiliferous bed of Chalk with *Inoceramus*, near the first shaft at the north entrance to Halstead Tunnel, and a dry upper valley of the Chalk (south branch of the Timberden valley) with six feet thickness or more of flints, the water standing at a level below the valley fully 100 feet deeper than it once stood. Lastly, the visitors viewed from the hill near Darent Holme, the residence of Mr. Prestwich, the trumpet-mouthed valley of the Darent, opening out into the Weald, but draining in the opposite direction into the Thames. The bearings of these facts upon the past hydrographical conditions of the Weald formed an interesting topic of discussion. The party were entertained by Mr. and Mrs. Prestwich at their mansion, Darent Holme, where a cordial vote of thanks was presented to the conductor through Mr. Walker and Professor Hughes. The return journey to town completed the day's proceedings.

ORDINARY MEETING, JULY 3RD, 1874.

HENRY WOODWARD, Esq., F.R.S., F.G.S. &c., President, in the Chair.

The following Donations were announced:—

"Quarterly Journal of the Geological Society," Vol. xxx., Part 2; from that Society.

"Abstracts of Proceedings of the Geological Society;" from that Society.

"Transactions of the Edinburgh Geological Society," Vol. i., Parts 1, 2, and 3; Vol. ii., Parts 1 and 2; from that Society.

"Proceedings of the Berwickshire Naturalists' Club," 1873; from that Club.

"Transactions of the Manchester Geological Society," Vol. xiii., Part 4 (1873-4); from that Society.

"Annual Report of the Cornwall Polytechnic Society," 1870; from that Society.

"Annual Report of the Leeds Philosophical and Literary Society," 1872-3; from that Society.

"Proceedings of the South Wales Institute of Engineers," Vol. viii., No, 5 ; from that Institute.

"El departamento de Ancachs y sus Riquezas Minerales," by A. Raimondi.

"The Deposition of Cretaceous Strata," by C. E. De Rance, F.G.S. ; from the Author.

"Earth Sculpture," by A. Geikie, F.G.S. ; from the Author.

"The Mining District of Cornwall and West Devon," by Henry Collins, F.G.S. ; from the Author.

"List of Works on the Geology, Mineralogy, and Palæontology of Hampshire," by W. Whitaker, B.A., F.G.S. ; from the Author.

"List of Works on the Geology, &c., of Cambridgeshire," by W. Whitaker, B.A., F.G.S. ; from the Author.

The following were elected Members of the Association :— Nathaniel H. B. Beardmore, Esq. ; A. J. Jukes Browne, Esq., F.G.S. ; Frank Trickett, Esq. ; Samuel Trickett, Esq. ; Captain G. H. White ; and Thomas J. Woodrow, Esq.

The following Papers were read :—

1. ON THE DEPOSITS NOW FORMING IN BRITISH SEAS.

BY G. A. LEBOUR, ESQ., F.G.S., F.R.G.S., &C.

I have limited my present task to a brief description of the principal constituents of British sea-bottoms, with particular reference to their distribution and its causes, only occasionally noting by the way the more obvious bearings which some of the phenomena described have upon geological theory. For minute analyses and all similar details I beg to refer those interested in them to M. Delesse's elaborate book.*

The materials forming the recent deposits of our seas are either of *mechanical*, *chemical*, or *organic* origin. The agencies by which these three kinds of sediments are distributed are rain, rivers, winds, tides, currents and the composition of the sea-water, which, in their turn, are all subordinate to the configuration of the sea-floor. What this configuration is may be easily perceived by examining the contour lines in M. Delesse's maps, the entire extent of the seas under our notice forming part of the great Old-World Plateau and reaching to its westernmost margin, beyond which we have the vast deep Atlantic desert, of which we have heard so much lately with its immensity of calcareous ooze.

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* "Lithologie du Fond des Mers," par A. Delesse. Paris, E. Lacroix, 1872.

ROCK BOTTOMS.

Confining our observation then to this high-land of the ocean, we first notice that in some places no deposit takes place at all, the bare rock being left exposed to the direct action of the water. These rock bottoms are, however, the exception, and occur usually in patches of limited extent and always where there are powerful and constant current streams. Thus the largest of these are in the western half of the Channel Valley, forming two great spreads, the one extending from the Land's End to the Brittany coast, and consisting apparently of crystalline rocks akin to those of the land on either side; the other stretching from the coast of Normandy nearly to that of Dorsetshire, and uniting the Lower Secondary rocks of France and England in the same manner. Immediately to the west of the Straits of Dover, and up to the very edge of the watershed-line, is another uncovered area, also extending nearly from shore to shore, and yielding chiefly chalk in the soundings. A somewhat large rock-bottom is to be found at the widest part of the Thames estuary *beyond* its deltal mud deposit, of which mention will be made in due course; smaller patches are known occupying a precisely similar position beyond the mouth of the Severn in the Bristol Channel. Large irregular-shaped rock-bottoms follow in the main the central portion of the Anglo-Irish sea, while numerous small ones are known along the west coast of Ireland, off the extreme north of Scotland, and in insignificant masses along the Yorkshire coast and elsewhere. The distribution of these bare spots is directly connected with that of currents, and that this is so is strikingly proved by the fact that they are by no means limited to any relative depth, for in the Channel at least their range extends entirely across the valley, and even in one place (to the north-west of Alderney) reaches the depth of more than 86 fathoms at the deeper end of a curious longitudinal oblique furrow called by M. Delesse the "Fosse Centrale" of the Channel.*

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* This long hollow is attributed by M. Delesse to a line of *fracture* not yet filled up. This view appears to me to be scarcely admissible. True, as he says, it cannot be itself due to the Channel currents. That it *influences* the deeper currents is shown by the fact that whereas the greater part of its length is gradually being

Other rocky areas have been met with at a very considerable distance from land and at great depth; thus one of them at more than 500 fathoms exists at the point at which the Atlantic Cable enters the yet deeper region of the Atlantic ooze. Most of the other deep-sea localities of this kind are, however, beyond the limits of British seas proper.

It is worth noting, before leaving the subject of Rock-bottoms, that in most cases the specimens brought up by the sounding instruments consist of much-weathered and *rotten* stone, thus attesting the kind of action which is exerted by the sea on uncovered rocks in its depths—an action chiefly of chemical disintegration and decomposition, *not* of mechanical degradation, even where powerful currents are present.

MARINE DEPOSITS.

Supposing the bed of the ocean were raised some 600 feet, we should perceive, in British seas, a vast expanse of *sand* with occasional islands of clay, mud, gravel, and shell-deposits, besides the uncovered rock-faces already alluded to. The broader the sea, the greater the proportion of sand. Thus the North Sea may, roughly speaking, be said to have its floor entirely covered with sand, the chief exceptions being a somewhat extensive space covered with mud to the north-east of Scotland, and beyond it a triangular area of clayey bottom, which may indeed prove to be merely decomposed schistose rocks *in situ*, and thus to belong properly to the true rock-bottoms. Towards the middle of the North Sea the sand becomes muddy over a considerable region; but the main character of the entire North Sea bottom is decidedly sandy. Due north again, from Scotland to the Faroë Islands, sand largely predominates, as it also does to the north-west as far as the islet of Rockall, just south of which reef, however, it assumes again a muddy character. To the west of Ireland likewise sand is beyond comparison the most prevalent bottom. South of Ireland, a large expanse of pure mud and muddy sand spreads itself to the south and south-east, reaching almost to the Land's End shell-deposit to be mentioned presently.

Sand merging into gravel and gravel itself are by no means as

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filled up with sand, its deepest point is kept free from deposit of any sort. Indeed this Central Fosse has all the characteristics of a true rock-basin, but whether or no it is due to glacial action is a question not to be tackled rashly. Its direction is about E.N.E.

frequent as might be expected, the only considerable deposits being off the French coast between Hâvre and Calais. All other submarine accumulations of the kind are small, unimportant, and very irregular in shape; they appear to be almost entirely confined to the Channel, with the exception, perhaps, of a patch to the south-east of the North Foreland.

Sand, sandy mud, and mud proper are distributed in about equal proportions in the St. George's Channel.

It is extremely difficult to be certain from soundings merely whether a clay-bottom represents a recent or an old deposit. Some of the shingle bottoms may also be looked upon as of doubtful origin, some being possibly the result of disintegration of submarine out-crops *in place*, while most of them are no doubt the result of transport from our shore pebble-beaches.

Most interesting of all deposits now forming in our seas are those which consist almost entirely of organic *débris*. These are the shreds of evidence to which, in the very doubtful event of their being spared by denudation, geologists of the far-future will have to trust for a record of the life of our seas during the present geological period. Very incomplete and fragmentary this record must needs be, even under the most favourable conditions of preservation. In the Channel the shell deposits attain their greatest development as regards British seas. They form two long, occasionally broken, lines following at a short distance the English and French shores and at the widest part of the Channel actually crossing the broad sea-valley, partly over and considerably to the west of the large Cornish-Breton spread of bare rock referred to above. Indeed the outer mouth of the Channel may be regarded as being one vast shell-bank. Elsewhere in the Channel the Gallic side is richer in shell deposits than the English, the bays of St. Brieuc and Cancale especially, and the great sweep from the Cotentin Peninsula to Calais containing deposits of a size unknown on the British side. The Straits of Dover put a stop to these organic accumulations, and the only considerable shell-masses beyond, in the North Sea, are: a tolerably large area to the north of Dunkirk, a smaller one between the Yorkshire coast and the western extremity of the Dogger Bank, an interrupted line of shell-banks trending from the Firth of Forth by the Long Forties and the Dutch Bank to the coast of Norway near Stavanger Fjord, and, lastly, one close inland in the northern portion of Dornoch Firth.

The northernmost in the British seas are: one north of Armadale, and further still a large bank to the south-west of the Faroë Islands. Several shell-beds line the sea-floor round the Hebrides, and far to the west beyond the ocean valley which lies between them and the Rockall Reef. Here also is a fish-bank more than three miles in length—a deposit formed entirely of fish remains, and giving us some inkling of the manner in which some of our long-fossilised fish-beds were originally accumulated.

Shell-beds are scarce off the west coast of Ireland, but are to be found to the north and south of the island, while they are numerous and extensive throughout the Irish Channel, especially in its central portion.

FLUVIO-MARINE DEPOSITS.

We now come to a class of deposits which are directly due to the transporting action of rivers, or in other words to *Submarine Deltas.* Of these the most marked is that of the Thames, which forms a large spread of arenaceous mud or silt in the shape of a triangle, the base of which runs from Margate to Foulness, and the apex of which stretches out to sea in a north-easterly direction. The Seine delta is about equal in size to and identical in composition with that of the Thames, but the reverse of it in this particular, that the wide base of its triangle faces the sea and its apex runs up the estuary. The Severn has no very well-marked submarine delta, although the muddy banks in the upper part of the Bristol Channel no doubt represent it. Mr. James Geikie describes the mud banks at the mouth of the Firth of Tay as forming a well-defined submarine delta * and doubtless a study of the soundings in the Admiralty charts with a view to following up the inquiry, would show that every river has its own more or less limited area of discharge in altering the materials of which currents and other marine distributing agents are powerless.†

SHORE DEPOSITS.

The history of shore deposits is in general so obvious, and it is so difficult to map their boundaries on any but the largest scale that it is not necessary to do more than mention them on the present occasion. It must, however, be borne in mind that in these littoral accumulations we have, in the rough, a large part of the material whence the sifted and re-assorted deposits of the deep sea are derived.

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* "The great Ice Age," 1874. Appendix p. 520.

† These submarine deltas can only be clearly recognized when the materials of which they consist are distinct from those forming the prevailing sea bottom. Thus the Thames, Seine, and Tay deltas are known because they are mud banks in a sandy sea. Those of the Volga, the Danube, the Nile, and the Ebro are also easily discovered because they form sand banks in mud-bottomed seas. Rivers bringing mud into muddy seas or sand into sandy seas, have deltas likewise, but it is in exceptional cases only that we can delineate their boundaries.

CHEMICAL DEPOSITS.

Of true chemical deposition it cannot be said that the comparatively shallow seas of Britain offer any good example, although doubtless much of the intimate composition of the muddy and marly deposits is owing to reactions effected by the constituents of the sea-water, and by the difference between surface and depth, and pertaining to various currents.

CONCLUSION.

It may be objected with some plausibility that some of the principal marine deposits at present in course of formation being of a perfectly incoherent nature, such as sand, not much reliance is to be placed on the mapping of the spaces covered by them. As regards deposits in shallow water this is no doubt true, the shifting of minor sand banks being a matter of common observation. I do not, however, believe either that the larger features even of rather shallow sea-bottoms are liable to important changes while the surrounding geographical conditions remain unaltered, or that any change save that which is inseparable from secular increase of thickness takes place in the deeper seas. In a narrow and shallow sea, such as the English Channel, a complex system of currents is ever at work together with regular tidal action in distributing the loose elements of the sea bottom—yet even here years of accurate observation have caused no change in the mapping of the reefs and banks, such as would be appreciable in a small-scale chart. The same agencies which sweep certain spots bare, heap up material elsewhere, and the relative form of both covered and uncovered portions of the sea-floor is preserved by them. Mud and clay once deposited in hollows can have but little tendency to be dislodged, and the same may be said of marly deposits. Moreover the limits assigned to such accumulations are not likely to suffer much alteration, since the almost microscopic particles of which they consist make it impossible for them to be released from suspension in the current streams except after the deposition of the more bulky and heavier grains of sand. Every patch of mud or clay the ingredients of which have been brought from a distance must to a certain extent be a centre of calm. The points of the greatest rapidity and violence of current action are shown by the bare rock patches; while the intermediate stages of agitation are represented by the other deposits, ranging from muddy sand, sand, sandy gravel, etc., to the coarsest shingle beds. Where, as in the North Sea, for example, the loose material of the sea-bottom is to a great extent homogeneous, the calm-spots will be marked by features only, and are therefore less noticeable.

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2. NOTES ON SPECIMENS OF PHOSPHORITE FROM THE DEPARTMENT OF THE LOT, FRANCE.

By F. W. RUDLER, ESQ., F.G.S., M.A.I., &c.

In bringing before the Association some fine specimens of phosphorite which have recently been brought to this country from Bach, in the Department of the Lot, and have been kindly placed in my hands by Mr. Walter Pearce, it may not be out of place to offer some remarks on the conditions under which the mineral occurs in this locality. The discovery of phosphorite in the South of France dates back to 1865, when a chemist named M. J. A. Poumarède, having returned from Mexico and settled near Caylus, in the Department of Tarn-et-Garonne, was struck with the appearance of certain nodular bodies which were abundantly scattered over the surface of the Oolitic limestone in his neighbourhood. On submitting some of these nodules to analysis he found that they were not carbonate, but phosphate of calcium. Although M. Poumarède was fully alive to the value of his discovery, he failed to follow it up at the time, and was soon afterwards removed by death. Attention, however, was seriously directed to these minerals on the conclusion of the Franco-German war; and since 1871 they have been actively worked in a large number of localities in the Departments of the Lot, Aveyron, and Tarn-et-Garonne.

The phosphorite occurs partly in regular veins running through the limestone, and partly in "pockets" or irregular deposits in cavities which, in some cases, reach a width of more than 100 feet. It will be seen from the specimens exhibited that the mineral frequently assumes nodular forms, with a beautifully concentric structure resembling that of a regularly formed agate; whilst other specimens show a finely banded structure, such as would be presented by a mineral deposited from solution in successive layers on the walls of a fissure. According to several analyses by M. Bobièrre, the French phosphorite contains on an average about 36 per cent. of phosphoric anhydride, corresponding to 78 per cent. of tricalcic phosphate. It also contains chlorine and fluorine, and it is notable that, as in the Bavarian and Nassau phosphates, iodine is present, presumably as iodide of potassium. The geological age of these phosphatic deposits may be inferred from the associated organic remains. Some of these fossils are now exhibited. The working of the French phosphorite has, indeed, brought to light a remarkable assemblage of mammalian remains, similar, in many respects, to those from the gypseous deposits of the Paris Basin. In addition, however, to the occurrence of *Anoplotherium*, *Palæotherium*, *Dichobune*, and other well-known genera, the deposits have yielded some new fossils allied to the lemurs, or Madagascar monkeys. One of these, from Quercy, has been described by M. Filhol, under the name of *Necrolemur antiquus*, whilst another new genus has been established by M. Delfortrie on some remains from Béduer. It has, however, been asserted by M. Filhol that the Béduer fossil, which had received the name of *Palæolemur Betillei*, is not a true lemur, but is even more interesting since it presents characters which bring it into relation with the lemurs on the one hand and with the pachyderms on the other. Those who wish to study the occurrence of the French phosphatic deposits and the organic remains which they have yielded may be referred to the recent writings of MM. Daubrée, Delfortrie, Durand-Clay, Filhol, Gervais, Leymerie, and Malinowski.

3. A PROBABLE ORIGIN OF THE PERFORATIONS IN SHARKS' TEETH FROM THE CRAG.

By H. A. BURROWS, ESQ.

As there exists in recent specimens a foramen for the passage of blood-vessels for the nutrition of the pulp filling the interior of the tooth, and opposite to this numerous small holes on the other side of the tooth, we may infer that the extinct large sharks also possessed similar holes in their teeth; but as the former hole coincides with the position of the hole found in the fossil teeth, we may conclude that the holes found in the fossil teeth were formed by the blood-vessels passing in at one side of the tooth, and that opposite, or nearly so, on the other side of the tooth, a branch vessel passed in or out, so leaving a hole, or may be several small holes, which, by subsequent friction or partial solution of the tooth became united into one hole passing completely through the tooth. All the perforated teeth are from the upper jaw.

The specimens of sharks' teeth from the Crag exhibited by Mr. Charlesworth are divisible into two classes:—

(*a*) Those in which the enamel is smooth, with serrations on the edges, and only one hole. Lithodomi markings absent.

(*b*) Those in which the serrations are gone, but extending over the surface of the tooth (more or less), are peculiar markings attributed to lithodomi.

Specimens of recent Sharks' Teeth on which the above is founded.

Large jaw showing difference between upper and lower teeth, and vessel passing through mucous membrane into tooth.

Portions of smaller jaw from which the teeth were obtained by maceration in water.

Two teeth showing cribriform character of foramen.

Outer wall of tooth removed to show interior chamber, with foramen communicating.

Specimen injected to show holes on opposite side of tooth.

Numerous specimens having holes at various places in the fang.

Tooth macerated in hydrochloric acid for a short time, and then dried, which shows peculiar markings similar to those attributed to lithodomi in the fossil teeth.

EXCURSION TO THE CHELTENHAM DISTRICT.

July 20th, 21st, 22nd, 23rd, 24th, and 25th, 1874.

Directors: Thos. Wright, Esq., M.D., F.R.S.E., F.G.S.; the Rev. W. S. Symonds, M.A., F.G.S.; W. C. Lucy, Esq., F.G.S.; and J. Logan Lobley, Esq., F.G.S.

(*Report by Mr. Lobley.*)

VALE OF SEVERN.

Members arrived at Cheltenham about mid-day, and were entertained at luncheon by Dr. Wright, who received the party at the railway station. That a general idea of the geology and physiography of the district might be obtained as early as possible, the afternoon of the first day was devoted to a visit to Churchdown Hill, an outlier of the Jurassic rocks of the Cotteswolds, standing well out in the Vale of Severn, a few miles south of Cheltenham. The summit was reached after a somewhat steep ascent, and the atmosphere being clear, a fine view of the great Vale of Severn was obtained. The Palæozoic western boundary from the Malverns to May Hill and the Forest of Dean was equally conspicuous with the Mesozoic Cotteswolds and their two outliers of Breedon Hill and Robin Hood's Hill on the eastern side, while the flat-bottomed vale of Trias, Lias, and Alluvium stretched far to the north and far to the south, with, in the midst, the Severn flowing past Worcester, Tewkesbury, and Gloucester, and broadening to its estuary. After describing the geology of the country within view, Dr. Wright pointed out that Churchdown Hill was a typical outlier, and corresponded stratigraphically with the lower portion of the Cotteswold escarpment, from which the outlier is distant about a mile, the base being composed of the Lower Lias, which rises to some distance up the hills, succeeded by the Middle Lias, with a small amount of Upper Lias forming the summit. Descending the hill, a visit was paid to the vicarage, at the hospitable invitation of the Rev. Dr. Smythe, F.G.S., who exhibited to his visitors a collection including local Liassic fossils. The party then returned to Cheltenham, and, in the evening, dined together at the Queen's Hotel.

THE COTTESWOLDS.

On Tuesday morning the Members proceeded in carriages to Leckhampton Hill, at the foot of which they alighted, and, walking up the gradually-ascending road, obtained more and more expansive views of the beautiful and well-wooded vale, with the wide-spreading town of Cheltenham, overshadowed by the neighbouring Cotteswolds. About mid-way to the summit Dr. Wright, with maps and sections spread on the hill side, described the Jurassic Series of Gloucestershire, one member of which—the Inferior Oolite—is typically represented at Leckhampton Hill, and is exposed as follows :—

Zone of Ammonites Parkinsoni, Ragstone	Upper Trigonia Grit Gryphite Grit Lower Trigonia Grit
Zone of Ammonites Humphresianus, Upper Freestone	
Zone of Ammonites Murchisoniæ	Oolite Marl Lower Freestones Pea Grit

At Frocester Hill and Nailsworth the sands above the Lias are well seen, and these the Doctor considered to be the equivalents of the Midford Sands, and of the similar sands in Dorsetshire, which in that county underlie the Zone of A. Humphresianus, the Zone of A. Murchisoniæ being there wanting. The cause of oolitic structure had never been satisfactorily explained, but Dr. Wright ventured to think that the minute nuclei which form the centres of the spherical grains were particles of coral which formed the fine coral sand that in the Oolitic sea doubtless lay on the coral reefs, three of which can be made out in the Inferior Oolite. The concentric calcareous layers would then be formed by the derivation of carbonate of lime from the water, and the spherical form would be produced by the rolling on the ancient beach. The upper portion of the hill is very steep, and tested the climbing powers of the Members to the utmost as the successive beds were searched for and examined. The "Pea Grit" was well seen resting on the Upper Lias, the highest point of which was found. After traversing the face of the escarpment for a long distance, and examining the lithological character of the various beds, the party descended the hill to the residence of Major Barnard, F.L.S., where luncheon was hospitably provided by that gentleman. Rested and refreshed, the Geologists again ascended the face of the hill, and at length reached the Gryphite Grit and the Upper Trigonia Grit at the summit, after much labour. Fossils were abundant, and testified the correctness of the names which had been given to these beds. The work of collecting was interrupted by a violent rain storm, which was bravely endured on the shelterless hill top. Leaving the edge of the escarpment, the Members made their way across the elevated plateau, the water parting between the Severn and the Thames hydrographical areas. Soon the land began to decline towards the east, and the head of the great Thames Basin was found to be a beautiful elongated and narrow dell covered with velvety turf, studded with small graceful trees, and gradually widening until the Cheltenham and Cirencester high road is struck. Near this point, in a little hollow by the roadside, the far-famed "Seven Springs," one of the sources of the Thames, were found. The pool formed by water issuing from the springs, which were with difficulty counted as seven, is very small, and the stream running from it—the infant Thames—is a diminutive rivulet that a boy may step across. No sooner is the river born, however, than it begins to work, the stream being utilised for a mill at a few yards from its source. The British name Coryn (now Churn) anciently given to the stream signifies the top or summit, and so was applicable to the head waters of the Thames. The Members having rested for some time, and listened to Mr. Parker's remarks on the etymology of the word "churn," took their departure from the interesting spot, and regaining their carriages, were swiftly conveyed to Cheltenham.

MAY HILL.

The Members having surveyed the Severn Valley from Churchdown Hill, and made themselves acquainted with the geology of the great Cotteswold escarpment on its eastern side, devoted Wednesday to the Palæozoic rocks forming the western boundary of the vale. The clump of firs crowning May Hill had formed a striking object in the view from Churchdown and from Leckhampton Hills on the two preceding days, and on this the third day became the destination of the party. Journeying by way of Gloucester City, the Geologists crossed the Severn, with the wide alluvial flats on either side, and after a short run entered the valley between the Forest of Dean and May Hill, and alighted at Longhope Station. An exposure of rock in an old quarry close to the railway station showed highly inclined Upper Ludlow strata, which here rise from beneath the Old Red

Sandstone forming the valley to the south, and extending to the Carboniferous rocks of the Forest of Dean. The little brachiopod, so characteristic of the Upper Ludlow, the *Chonetes lata*, is most abundant, and good specimens were easily obtained. On higher ground another old quarry gave an exposure of Wenlock Limestone yielding *Strophomena depressa, Favosites Gothlandicus*, and *Catenepora catenulatus*. A spur of May Hill was then crossed, and after a slight descent the great symmetrical dome-shaped mass called May Hill was ascended. There are few spots of English ground possessing greater interest to the geologist than the summit of the hill which gave name to an important member of the Silurian System, and which overlooks land formed of every formation from the Cambrian to the Oolites. To quote from "The Record of the Rocks," the charming work of the Rev. Mr. Symonds, "Nowhere in this part of England is there a nobler view! To the north rise the ancient Malverns, the Silurian rocks of Ledbury and Woolhope are clothed with wood, and to the north-westward peep out in the distance the Welsh mountains of Old Red Sandstone, with here and there an outlier of Carboniferous rocks telling of the history of denudation between points so distant as the Pen Cerrig Calch, near Crickhowell, and the Clee Hills in Shropshire. Westward is the Forest of Dean, with its Old Red base, and all the Carboniferous Series on its summits; and eastward is the Severn, wandering by the old Norman cities of Worcester, Tewkesbury, and Gloucester, among the battle fields of centuries, by ancient cathedrals, abbeys, and churches, until it expands into its fine estuary; and far away to the south we see its glistening waters bordered by the Cotteswold, the Mendip, and the Quantock Hills." The May Hill Sandstone or Upper Llandovery forms the upper portion of the hill, while Wenlock and Ludlow strata are seen around the base, the whole being probably the result of the same great upthrow of Silurian rocks, which formed the Valley of Woolhope, visited by the Association, July, 1873, May Hill being on the axis of the Woolhope valley, and exhibiting rocks of the same age. The Upper Llandovery rock is well exposed on the hill, and consists of beds of sandstone of various degrees of coarseness, in which the little coral the *Petraia* presents itself abundantly. On the summit Mr. Lobley described the geology of May Hill, and pointed out the many points of geological interest within view. The party lingered on the summit reluctant to leave, then descended, and after a rapid walk reached the railway, and returned to Cheltenham.

GARDEN CLIFF.

On the fourth day the party, under the guidance of Mr. W. C. Lucy, F.G.S., visited the fine Rhætic and Lower Lias sections of Garden and Frethern Cliffs on the banks of the Severn, near Newnham. The train was taken to Grange Court, whence a pleasant walk through fields and orchards brought the Geologists to Westbury-on-Severn, and a little further to Garden Cliff. It being low water in the Severn a good general view of the cliff was obtained from a point well in front, and here Mr. Lucy described the section, the details of which he gave as follows:—

	Lias.—Lower Lias *A. planorbis*, *Ostria Liassica*.	ft.	in.
Rhætic Series.	Bed with *Modiola minima*	0	3
	Bed with *Monotis decussata*	1	6
	Bed with *Modiola minima*	0	5
	Bed with Fish remains	3	6
	Bed	3	0
	Estheria zone	1	0
	Bed	0	6
	Bed with *Pecten Valoniensis*, *Cardium Rhæticum*, *Axinus cloacinus*, *Anatina*, *Suessi*, *Lima precursor*, *Myacites musculoides*, *Pleurophorus angulatus*, *Modiola minima*	7	0
	Upper Pecten Bed—*Plesiosaurus*		
	Bed	2	0
	Lower Pecten Bed.		
	Avicula contorta Shales	2	6
	Cardium Rhæticum Shales	7	0
	Bone Bed *Acrodus minimus*, *Gyrolepis Alberti*	0	1
	Bed	0	6
	Bone Bed *Nemacanthus*, *Saurichths apiclis*, *Pullastra arenicola*	0	1
	Bed	1	6
	Pullastra Bed—*Cardium Rhæticum*, *Modiola minima*, *Avicula contorta*, *Pullastra arenicola*	1	0
	Bed	1	10
	Bed *Gyrolepis Alberti*, *Sargodon Tomicus*, *Pullastra arenicola*, *Saurichthys apicalis*, *Avicala contorta*	0	5
	Bed	1	3
	Bed, Coprolites, Teeth, Scales	14	0
	Red Line.		
	Bed.	3	3
	Keuper—Alternating Beds of Red, Grey, and White Marls.		

The dip of the beds allows of each being examined with ease as the observer proceeds along the base of the cliff to the south-east, geologically higher and higher beds forming the lower portion of the cliff. This was taken full advantage of, and under Mr Lucy's excellent guidance a careful inspection of the various beds was made, and characteristic fossils, which in some of the zones are plentiful, were collected. Much enthusiasm was displayed, notwithstanding a heavy downpour, by Members in searching for and discovering the fossil zones, several of which are very thin, and require careful search and an experienced eye for their detection. Returning to the north-west end of the cliff the somewhat tired Geologists sat down to an *al fresco* luncheon, and awaited the boats, which had been ordered to convey them to Frethern. At length with the rising tide the boats appeared in sight, and all embarked, but half of the party merely used the boats for crossing the river, and landed on the opposite bank, whence they made their way on foot to Frethern Cliff, where they were joined by the boat party, but time only admitted of a hurried inspection of this fine Lower Lias section, as Severn bank was traversed *en route* to the Berkeley and Gloucester Ship Canal, by which the now quite tired Geologists returned on board a quickly sailing steamer to Gloucester. Notwithstanding the fatigues of the day a visit was paid to the Gloucester Museum, under the guidance of Mr. Baldwin, who has contributed to its geological stores, and many illustrations of the local geology here attracted the attention of the visitors. After dining together at Gloucester the train was taken to Cheltenham.

TEWKESBURY, APPERLEY, WAINLODE CLIFF.

The fourth day having been given up to the banks of the Severn below Gloucester, the fifth was occupied by visits to Tewkesbury, Apperley, and Wainlode Cliff on the river above that city. Leaving Cheltenham early, the party proceeded by carriage along the Tewkesbury Road. At Coombe Hill a good section of the Rhætic or Avicula Contorta Series was examined, and Dr. Wright explained his reasons for preferring the latter name, originally given by him to these beds which are so persistently characterised by the *Avicula contorta*, both in this country and abroad. On arriving at Tewkesbury, the Members were met by the Rev. W. S. Symonds, the Director for this day, and Sir William Guise, Bart., the President of the Cotteswold Club.

Before leaving the town, Tewkesbury Abbey was visited at the invitation of the Vicar, who read an interesting paper on the history and archæology of the grand old pile, in which many of those slain in the sanguinary and decisive battle of Tewkesbury, including the Prince of Wales and the Duke of Somerset, lie buried. Mr. James Parker followed with a learned discourse on the foundation of the church by Dodo and Odo, the Saxon Dukes of Mercia, in the eighth century. The party on leaving the Abbey assembled before the great west entrance, when a photograph of the group was taken for publication, as a memorial of the visit. Mr. Symonds then led the way across the "Bloody Meadow," the scene of the slaughter of 4000 Englishmen, to Tewkesbury Park, the site of the great-battle, formed, for the most part, of the higher level gravels of the Severn Valley. On the high ground stands the mansion of Tewkesbury Park, and here, the focus of the contest, Mr. Symonds gave an eloquent account of the Battle of Tewkesbury, in which he depicted most vividly the encounters that had occurred on this spot in 1371. The old estuary gravels, containing remains of existing Mammalia, slope down to the alluvial river flats, where no less than 150 feet thickness of silt has been found without any such remains as those yielded by the gravels.

A pleasant walk through the river-side meadows, brought in sight the ancient church of Deerhurst, where Mr. James Parker again gave proof of his archæological lore by a most interesting, as well as most learned lecture on this little country church, respecting the origin of which there is better documentary evidence than for that of any other of Saxon age. Mr. Parker exhibited a rubbing of the dedication stone, of the date 1056, which states Odda to have been the founder. But the tomb of Hugh Strickland, the predecessor of Phillips at Oxford, and the memorial window erected to his memory, rendered Deerhurst church specially interesting to its geological visitors, who thus reminded of his distinguished though brief career, left Deerhurst for Apperley, Strickland's old home. Then crossing the park the river was again reached, and a short walk by its verdant banks terminated at Wainlode Cliff, another fine section of the Rhætic Series, first examined by Strickland. Dr. Wright and Mr. Symonds described the section, in which the Rhætic Black-shales are very finely displayed. The shales were examined, but few organisms were found.

Returning to Apperley the Members were received at Apperley Court by Miss Strickland, the sister of the distinguished geologist, who had invited the party to dinner. Apperley Court commands a view over one of the richest portions of the Vale of Severn, and stands in a park of great beauty. After dinner Mr. Symonds and Dr. Wright spoke of the teachings of what had been seen during the day, and the associations of the house in which so many geologists were then assembled. Sir William Guise, Mr. Parker, Mr. John Jones, and Mr. Lobley also addressed the assembly, and Miss Strickland expressed the great gratification which this visit of the Members of the Geologists' Association afforded her, and invited her guests to inspect the collection of mammalian remains obtained from the Severn Valley gravels by her brother. This interesting visit terminated by very cordial thanks being given to the hospitable owner of Apperley Court, when her guests took their departure, and after a rapid drive returned to their hotel at Cheltenham.

STROUD.

On the succeeding day, the last day of the Excursion, only a small number of Members returned to London, visiting *en route* Stroud and its neighbouring hills of Oolite. Those who did so, however, saw to advantage the deep valleys cut through the Great and Inferior Oolites which characterise this part of Gloucestershire. Rodborough Hill of Inferior Oolite, so famous for its abundant fossils, and the Great Oolite quarries on Minchinhampton Common were examined, and yielded a large number of fossils to the vigorously-used hammers of the party. The train was then taken for London, and the week's proceedings terminated.

ORDINARY MEETING.

NOVEMBER 6TH, 1874.

HENRY WOODWARD, Esq., F.R.S., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

"Quarterly Journal of the Geological Society," Vol. xxx., Part 3; from that Society.

"Abstracts of Proceedings of the Geological Society;" from that Society.

"Smithsonian Report for 1872;" from the Smithsonian Institution.

"Transactions of the Edinburgh Geological Society," Vol. ii., Part 3; from that Society.

"Transactions of the Manchester Geological Society," Vol. xiii., Part 5; from that Society.

"Proceedings of the Winchester and Hampshire Scientific and Literary Society," Vol. i., Part 3; from that Society.

"Proceedings of the Somersetshire Archæological and Natural History Society," Vol. xix. (1873); from that Society.

"Proceedings of the South Wales Institute of Engineers," Vol. viii., No. 6, and Vol. ix., No. 1; from that Institute.

"Report of the Bristol Naturalists' Society" (1874); from that Society.

"Report of the Leeds Philosophical and Literary Society," 1873-4; from that Society.

"Report of the Warwickshire Natural History Society," 1874; from that Society.

"The Linguist," Vol. i., No. 1; from the Editor.

"Notes on the Geology of the Neighbourhood of Wells," by H. B. Woodward, Esq., F.G.S.; from the Author.

"On the Causes of Art, with an Outline of the Origin and Progress of Art," by John S. Phené, F.G.S., &c.; from the Author.

The following were elected Members of the Association:—

A. C. Maybury, Esq., D.Sc.; and George Chiswell Rowley, Esq.

The President, Henry Woodward, Esq., F.R.S., F.G.S., &c., then delivered the Opening Address of the Session 1874-75. (See page 1 of the present volume.)

ORDINARY MEETING.

DECEMBER 4TH, 1874.

HENRY WOODWARD, ESQ., F.R.S., F.G.S., &c., President, in the Chair.

The following Donations were announced:—

"Quarterly Journal of the Geological Society," Vol. xxx., Part 4; from that Society.

"Abstracts of Proceedings of the Geological Society;" from that Society.

"List of Fellows of the Geological Society," 1874; from that Society.

"Royal Cornwall Polytechnic Society—Report 1873;" from that Society.

"Journal of the Quekett Microscopical Club," No. 27; from that Club.

"Abstract of Proceedings of the Liverpool Geological Society," 1873-4; from that Society.

"Taylor's Calendar of the Meetings of the Scientific Bodies of London" for 1874-5.

"Glossary of Fossil Mammalia," by J. E. Gore, A.I.C.E.,; from the Author.

"On the Gault of Folkestone," by F. G. H. Price, F.G.S.; from the Author.

"Notice sur la Faune Marine du Terrain houiller du Bassin Septentrional de la France," par M. Charles Barrois; from the Author.

"Catalogue des Poissons Fossiles du Terrain Crétacé," par M. Charles Barrois; from the Author.

"Etude sur le Terrain Crétacé," par M. Charles Barrois; from the Author.

The following were elected Members of the Association:—

Stephen Austin, Esq.; Major R. Carey Barnard, F.L.S.; Edward Berry, Esq.; D. C. Davies, Esq., F.G.S.; Major Francis Duncan, M.A., D.C.L., LL.D., F.G.S., F.R.G.S.; Miss Emily Faust; Miss Jelley; Julius Maier, Esq., M.D.; R. H. Pearson, Esq.; Rev. M. F. W. Ralph; Rev. S. J. W. Sanders, M.A., L.L.M., F.G.S.; and J. J. Harris Teall, Esq., B.A., F.G.S.

The following Lecture was delivered:—

ON THE CONDITIONS WHICH DETERMINE THE PRESENCE OR ABSENCE OF ANIMAL LIFE ON THE DEEP SEA BOTTOM.

By Dr. W. B. CARPENTER, F.R.S., F.L.S., F.G.S., Corresponding Member of the Institute of France, &c., &c.

It is, of course, quite unnecessary for me to point out to the Members of the Geologists' Association, that the foundation of the whole of geological science—that is, the interpretation of the phenomena presented to us in the study of the earth's crust—must be based upon the study of the changes at present going on upon the surface of the earth, of course including the depths of the sea. This may be considered as the distinct feature of modern geology, when it is compared with the geology of the earlier part of this century; and I think it will be generally admitted that there is no one who has done more to place the science upon this sound basis than Sir Charles Lyell. I do not say that he stood alone, but I think that it will be generally admitted that there is no one who has done more to lead or to direct the course of geological inquiry in this truly scientific and only trustworthy manner.

Now, until recently, the knowledge of the conditions which prevail over the deep sea bottom has been, I may say, almost nothing. The very depth of the ocean, not many years ago—quite within my own recollection—was so uncertainly known that it might be regarded, in fact, as not known at all. We heard of depths of six or eight miles, and of other parts of the ocean as unfathomable. Now, at the present time, we are confident that these statements have no satisfactory foundation. That amount of sounding line might be paid out, and no bottom struck; but it did not at all follow that the sea had anything like the depth corresponding to the length of that line. The American surveyors, some years ago, devised a new method of sounding, which I must not stop to detail to you, but the principle of which is now universally accepted. It is one which so far avoids the errors of the older method, that there is no part of the ocean yet examined, in which a bottom may not be found, with a considerable degree of certainty, or, at least approximation to certainty, as to the depth at which it lies. And there is no trustworthy sounding, so far as I am aware, that goes beyond the depth of about four miles and a quarter. You may have heard of a recent sounding taken in the Pacific, towards the coast of Japan, in which a far greater depth than this was recorded; but I utterly distrust that statement. The sounding was taken in the line of a strong surface current—the *Kuro Siwo*—the Gulf Stream of the Pacific, as it is sometimes called—the warm current that is the reflex of the Equatorial current of the Pacific, turned towards the north-east by the coast of the Philippine Islands, of China, and of Japan; and knowing the difficulty which Captain Nares, with all his experience, had in obtaining a trustworthy sounding through the Gulf Stream, I feel a strong conviction that, unless we have an adequate assurance that the method employed was one which would overcome that difficulty, we may distrust the statement that a depth of eight miles was obtained.*

At present, then, it has been quite clearly ascertained that the general depth of the Atlantic does not exceed three miles. In some places, however, it sinks deeper. The most remarkable sounding that was taken in the "Challenger" survey of the Atlantic, was one which gave a depth of 3,800 fathoms; that is about 4¼ miles; and this was apparently in a deep hole, 100 miles to the north of St. Thomas's. The "Challenger" was on her way from St. Thomas's to Bermuda, and unexpectedly came upon this tremendous depression. Captain Nares was very confident, from the stillness of the water, and the circumstances under which the sounding was taken, that it was a 'true sounding; and there was one very curious fact that proved that the depth was very much greater than that which had been previously taken, namely, that the two thermometers sent down were both crushed. These thermometers had been tested with 3¼ tons on the square inch, which is equivalent to that of water of 2600 fathoms' depth. The pressure to which they were subjected would be about 4¾ tons at that depth of 3,800 fathoms; and the fact that they were crushed, you see, shows that they had gone down to a greater depth than that to which they were tested.†

Hence, you see, it has only been comparatively recently that we have known anything about the real *depth* of the sea. And it is only still more recently, that we have known, with accuracy and certainty, the *temperature* of the sea bottom. Various observations have been taken in different voyages upon this point. Everyone interested in physical or geological or biological inquiry knew perfectly well that this was a subject of very considerable importance; but unfortunately the greater number of observations taken upon this point have been entirely untrustworthy, in consequence of allowance not having been made for the effects of pressure upon the thermometers. This point, I its temperature in a non-conducting wooden vessel, whilst coming up through the upper warmer strata. According to a formula, which Biot, the celebrated French physicist, devised, a certain reduction from the actual temperature of this mass of water was made for the increase of heat which it might undergo through being brought up through the warmer superstratum. The barrel, I should say, had two valves, both opening upwards. It was considered that, while it was sinking, the water would stream up from below through the valves. Then when the barrel was being hauled up again, the valves would be closed down by the superincumbent pressure, and the water taken in at the bottom would remain in the cask, and would be brought up to the surface; thus bringing up, as it were, the temperature of the deep stratum, with a certain amount of alteration produced by the water having to ascend through the warmer superstratum. This was a clumsy and an excessively laborious process, because the hauling up of a sufficiently large cask from such a depth in the ocean we should have thought could only have been done by a powerful donkey engine; and the Russian sailors must have toiled at the capstan a great many hours to be able to make only one observation.

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* The official report of the "Tuscarora" soundings, which has since come into my hands, shows that depths somewhat exceeding *five* miles were found in this position by the use of Sir William Thomson's sounding-wire.

† A depth of about 4,500 fahoms, or more than *five miles*, has since been met with by the "Challenger" near the north coast of New Guinea. In this last sounding, taken with a hempen line, three out of four strongly "protected" thermometers were crushed by the tremendous pressure.

Now it is a very remarkable circumstance that Lenz's observations gave him a series of temperatures which correspond very closely indeed with those obtained in the "Challenger;" and they are by far the best series of observations which were made antecedently to the "Challenger" expedition—I mean in the great oceans. The general conclusions drawn by Lenz were published only in a little incidental notice in the "Bulletin of the Academy of St. Petersburgh," which I believe has escaped the notice of other scientific men almost entirely, until Professor Prestwich dug it out; but these conclusions accord so precisely with those to which I had myself been led, that if the two had been put in parallel columns, it might have been almost supposed that I derived my ideas from those previously put forward by Lenz. But no one whom I ever spoke to on the subject, gave me the least idea that Lenz had previously arrived at them. No physicist, I believe, either in France, Germany, or Great Britain, was at all acquainted with them; and the conclusions which I myself have drawn, I drew entirely from the observations in which I had myself taken part.

I must come at once to these conclusions, without detaining you upon the mode in which they have been arrived at. The first of them is that in the great oceanic area communicating with the polar basins, there is a flow of polar water from each polar area towards the Equator. This has been most clearly worked out in the case of the Atlantic basin, which has a communication, as you well know, with both the north polar and the south polar areas. But the communication of the South Atlantic with the Antarctic area is perfectly free and unrestricted; there is nothing whatever to narrow it or diminish it. On the other hand, the communication of the North Atlantic with the Arctic area is a comparatively limited one. You must not draw your ideas on this point from a Mercator's chart. You know perfectly that in a Mercator's chart all the distances of the polar portion of the chart—both the north and the south polar portions—are immensely exaggerated. You should draw your conclusions from looking either at a globe, or at a chart of the polar portion in which the Pole is made the centre. You will there see that the communication between the North Polar area and the North Atlantic is really a very narrow one; the only communication of any breadth being that between Greenland and Iceland, and that is much narrower than you would judge it to be in looking at an ordinary map. Between Iceland and the Faroe Islands there is another communication; but, though the map does not show it, the hydrographer knows that this is a very shallow one. There is a bank running from the Faroe Islands, and almost touching Iceland, that is not more than from 200 to 300 fathoms in depth; and that is really the coast-line of the deeper portion of the polar area. Between the Faroe Islands and the north of Scotland, there is a narrow channel, which was the first scene of our explorations, and which I call the "Lightning Channel." It lies between the Faroe Islands and the 100 fathom line which you will see marked in all charts of the British Islands, and which is the boundary of that remarkable platform upon which all the British Islands are situated. If the whole of our corner of Europe were elevated not more than half as much again as the height of Saint Paul's—600 feet—not only would all the British Islands be brought together, but the land would be extended considerably to the north and west; the North Sea would be almost entirely extinguished, that is to say, it would become dry land, with the exception of a deeper channel near the coast of Norway; and Great Britain would be united with Denmark, with

Holland, with Belgium, and with France, the British Channel being no where 100 fathoms deep.

Now, between the northward extension of this 100 fathom platform, and the similar elevation which forms the Faroe Banks, there is a channel of from 500 to 600 fathoms' depth, to which our course was directed, as the nearest deep water that was to be obtained within easy reach of our own coast. I shall presently state to you the remarkable phenomena which that channel presents. This is one of the feeders, as it were, of glacial water to the Atlantic; but it is a little rill in comparison with the great, vast area of the North Atlantic. I have no doubt whatever that it will be found, if the Admiralty will take means to ascertain it in the intended Arctic Expedition,* that the whole of the lower portion of the channel between Greenland and Iceland, which extends to 1,200 fathoms' depth, and which was sounded from the "Bulldog" some years ago, when Dr. Wallich went out with Sir Leopold McClintock, gives passage to a flow of glacial water—of water at or below the temperature of the freezing point of fresh water (32° Fahr.),—and is the principal feeder of the cold stratum which extends over the bottom of the North Atlantic. But if you consider how narrow is that channel in comparison with the great broad area of the North Atlantic, you will perceive at once that the communication between the North Atlantic and the North Polar area, or Arctic basin, is a very limited one. On the other hand, the communication between the South Polar area or Antarctic basin and the South Atlantic is perfectly free.

Now, it was the study of this channel which first led me to the doctrine which I have since advocated, of the existence of two flows in the great oceanic area, which are quite unrelated to any sensible current. I put out of view altogether the Gulf Stream, or any other of the great surface currents. The Gulf Stream—I mean the true Gulf Stream which issues from the Gulf of Mexico through the Florida Channel—is entirely a product of the action of the Trade Wind on the equatorial Atlantic, driving it into the Carribean Sea and Gulf of Mexico, and then forcing on the current through the Florida Channel to come out as what we call the Gulf Stream. That has a certain superficial spread, but it is a mere surface current. The great movement which I am about to describe to you has a much greater depth and a much greater volume. This surface current is, in fact, when you look at it in sectional area, a mere little rill in comparison with the immense breadth and depth of the North Atlantic; and I believe we may say with confidence that the true Gulf Stream dies out in the mid-Atlantic. I must not go into this question farther; but it is one which is of very considerable interest. I shall have the pleasure of presenting to the Association a copy of a paper in which I fully discuss this subject, and, therefore, my views upon it will be accessible to the Members.

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* The "Valorous," which has accompanied the "Alert" and the "Discovery" to Disco Island as a store-ship, is charged with the duty of carrying out on her return voyage a series of observations on the Physical and Biological conditions of the North Atlantic.—W. B. C.

We found in the "Lightning" Channel, that there was a superficial warm stream, and a deep cold stream; and that we pass from one to the other within about 50 fathoms, finding a most marked difference of temperature. We found, for instance, that at two places within twenty miles of each other, the bottom had 13 or 14 degrees' difference in temperature; for whilst at one the temperature went down pretty regularly from about 52° or 54° at the surface to about 43°, at the other, it would go down at the same slow rate for about 100 or 150 fathoms, and then would descend rapidly, until it would come down to 32°, or even 30°, at the very same depth at which we found it 43° elsewhere. This is expressed in Fig. I., in which the depths are indicated by the vertical lines, and the degrees of Fahrenheit's thermometer by the hortizontal lines.

You will see here that in No. 87, starting from a surface temperature of 53°, the thermometer went down at 100 fathoms to about 47°, and then remained nearly the same at different successive depths down to about 500 fathoms, where it fell to 45°; between this and 777 fathoms it went down to 41°; and a further descent would have been shown if the thermometer had gone deeper. On the other hand, in No. 52, taken in the cold area, falling at precisely the same rate in the upper stratum, and reaching 45° at 200 fathoms, it sunk down rapidly to 30°5 at 300 fathoms, and showed the same at 384 fathoms. In No. 64, the upper warm stratum was cooler and thinner, and the descent of the thermometer more gradual; it showed 32° at 300 fathoms, 30° at 500, and 29°·5 at 640. Now, what is the meaning of this? It can have no other meaning, in my mind, than that there are two distinct movements of water. Whenever we have sudden and striking

changes of temperature, we know that there has been a change of wind. We all know, for instance, that a northerly and north-easterly wind brings a low temperature; and if, on the other hand, in the course of a few hours we have a rise of 10 or 15 degrees of temperature, we know that the wind must have changed, and has come from a southerly source. Well, here it is still more certain with regard to the movement of water. It is perfectly clear that glacial water of this kind, much colder than the lowest mean winter temperature of the latitude, could only have come from a northern source. I shall presently show you how much hangs upon that. On the other hand, where we find the temperature higher than the normal temperature of the latitude, the water must have come from a southern source. There can be no doubt, I think, in the mind of anyone, that there was a warm flow—that this surface flow was coming up from the south-west. It would be called in popular language a branch of the Gulf Stream; I shall show you that there is another account to be given of it. At any rate this polar water must have come down from the north-east; and, in perfect accordance with that derivation, we found that the animals of this cold area were all animals of Spitzbergen, Greenland, and Iceland—animals known to belong to the boreal fauna. There was one very remarkable form, the beautiful large *Comatula Eschrichtii*, well known as a Greenland and Iceland form, which we could get in any quantity on this cold area. The shells of the Echinodermata generally, Mollusca and Crustacea, were the animals of the cold area. There was one curious thing about the echinoderms, and that was that we found our familiar British forms dwarfed in a peculiar manner. The common *Solaster papposa* of our own seas, with which anyone who has dredged our own shores is familiar—the twelve-rayed star-fish, of which a fair-sized specimen would be of about the size of a pudding plate—was dwarfed down to about the size of a crown piece. So the ordinary five-rayed star-fish was dwarfed down to about a star of the same proportion. It was not that these were young specimens, because we got any quantity of them, all small—none larger than I have described.

That shows you, then, the influence of Temperature in determining the character of the Fauna. Now, the fauna was an abundant one, showing that even this low temperature of under 30° Fahr. did not prevent an abundance of animal life. Here, then, is the first condition I have to speak of—that temperature will determine the kind of animal life; but that no temperature we know, as yet, to be found on the sea bottom, is so far inimical to animal life as to prevent its existence. Cold may dwarf the fauna, may limit the variety and number of its forms; but I do not think that, as long as sea water is liquid, there will be any temperature that can be reached, which shall not be consistent with the existence of animal life.

Now, then, with regard to Pressure. I have already spoken of the tremendous pressure under which animals must live, because, of course, the pressure upon animals is the same as the pressure upon a thermometer. We know that the pressure is about a ton per square inch for every 800 fathoms of sea water; a column of sea water one inch in section, and 800 fathoms high—4,800 feet—weighing just one ton. Every animal, then, that is living on the sea bottom must be living under that pressure; but I need not explain to those whom I may presume to have some knowledge of physics, that this pressure, being equal in every direction, will not in the least degree affect any vital functions. You must bear in mind that water is almost incompressible. The difference between the specific gravity of bottom water under three miles' pressure, and that of surface water, will not be equal to the difference between the specific gravity of sea water and that of fresh water, the amount of compression being extremely small. Now, think of how this pressure will act. We will first take the simplest idea of an animal. Let us suppose a globular film—a globular bag of the most delicate possible membrane; and that globular bag has a hole in it for a mouth, with tentacles round the hole. That is just the simplest form of an animal possessing a stomach. Now, if that was globular at the surface of the water, it would be globular under any pressure, because, whatever the pressure outside may be, the pressure inside will be exactly equal to it. The animal can contract and expand just as well under a pressure of three tons to the square inch, as it can upon the surface. The pressure will have no effect in modifying its conditions; and you may judge of that by the fact that we ourselves are living under a tremendous pressure, which very few people realise. A man of my height, for instance, will have an atmospheric pressure of somewhere about 20 tons upon his surface, and a difference of the barometer such as we had last Saturday will exert upon him a difference in pressure of somewhere about two tons; and yet in what a perfect ignorance we are left of this change, by any feeling that we experience. You must bear in mind that the reason why a human being cannot be subjected to a pressure of this kind under water, is simply that his cavities contain air. These creatures of the sea are entirely made up of water and of what the water contains. There is no air in them, except the air in solution in the water. There is nothing that can be compressed. If we go down and subject ourselves to the pressure of four or five atmospheres, it is the pressure upon the air in our chest that disturbs the circulation; the whole of its conditions being altered by the inclusion within our bodies of this elastic fluid—the air. Pressure, therefore, I believe, we may say, has no direct influence on animal life. I will not say that an animal suddenly changed from one pressure to another—suddenly carried down, for instance, from the surface to a depth at which it would have to sustain a pressure of three tons to the square inch—might not be in some degree deranged or disturbed; or that an animal quickly brought up from that depth to the surface might not be somewhat deranged or disturbed; still the animals lived, and moved, and walked about when they were brought up from these great depths. And if the change were gradual, I believe that there is no depth at which, as a mere matter of pressure, animals might not exist. But you will presently see that there are some other considerations which enter into this question.

If, then, depth has no influence as regards pressure, if temperature has no influence, you will ask, "What has an influence?" I believe, more than anything else, the supply of Oxygen; and I will now explain to you the conditions under which, as it appears to me, the deep Ocean is placed, in contrast with the conditions of such an Inland Sea as the Mediterranean.

This under-flow of polar water over the deep sea bottom, of which we have now the most distinct proof from temperature-observations, has been sometimes spoken of as the flow of polar currents. Lenz, I believe, first put forward the doctrine that it is a general flow extending over the ocean-bottom, not limited to any particular passage or area. This was the view to which I was myself led—that it is a general flow; and that there will conversely be a general flow of the upper stratum from the Equatorial towards the Polar areas; and it seemed to me that this would depend upon, or be maintained constantly by, the difference of specific gravity produced by the difference of temperature.

You must, in the first place, bear in mind that sea water is quite differently circumstanced from fresh water, in regard to the effect of temperature upon its density. Fresh water, as you know very well, contracts down to 40 degrees, or about 39½ degrees, and then expands again. So that the water just going to freeze at 32° is really as bulky as the water at about 47°. I have sometimes illustrated it in this way, which perhaps some present will find to convey a more distinct idea to their minds than the mere statement of the fact. Suppose you have what we may call a water-thermometer and a mercurial thermometer side by side—a tube and bulb forming each; you fill the bulbs and tubes up to a certain point, and you note that point. When you immerse both bulbs in a freezing-mixture, the mercury will go on sinking and sinking, until it comes down to the point which you may have previously determined to correspond with the freezing point of water, viz., 32°. The water in the water-thermometer will sink and sink down to about 39½°, but then it will rise again. While the water is actually getting colder in the tube, it will rise again, because the water, in cooling below 39°, is also expanding—becoming more bulky; and when just about to freeze, it will stand where it stood when it had been cooled down to only about 47°. But *sea*-water will go on, like mercury, diminishing in bulk down to its own freezing point, not only to the freezing point of fresh water, but down to the freezing point of sea water, which is about 27° if the water is agitated, or 25° if it is kept perfectly still; and it is just before it freezes that sea water has the greatest density—that is to say, it is then the smallest in bulk, or of the highest specific gravity. Now, then, you at once see that if it has increased density with cold, colder water will, bulk for bulk, be heavier than warmer. A column of water at, we will say, 27° will be considerably heavier than an equal column of water at, we will say, 50°; and, therefore, when there is free communication between two such columns, through the oceanic area, since the polar column will outweigh the equatorial column, and since the lateral as well as the bottom pressure will be greater, there will be a lateral outflow at the bottom of the polar area, which will extend itself continuously towards the equatorial area. Then, on the other hand, this will cause a lowering of the water in the polar area, which will produce an indraught towards it; and there must, therefore, be a continual flow of the upper stratum from the equatorial towards the polar area. Further, the cold water streaming from each polar area towards the equatorial, and there meeting the polar flow from the other end, will rise up in the equatorial area, to compensate for the draughting away of the upper stratum, and will thus bring cold water nearer to the surface under the Equator than it is anywhere else, except where the surface is itself subjected to cold.

In some lectures which I gave three or four years ago, I illustrated this by a piece of apparatus which I was able to obtain at the Royal Institution, namely, a long glass trough with glass sides. I had a piece of ice wedged in at the surface of one end of the trough, and a heated plate on the surface of the water at the other end. Now, what is the effect? As soon as we put in some coloured liquid at the cold end of the trough, it fell down to the bottom; for by coming into contact with the ice, its specific gravity was so much increased that it at once sank; it then crept along the bottom towards the warm or equatorial end, and it came up under the heated plate. Being then heated by contact with the plate, it went on, as warm surface-water, from the equatorial to the polar end of the trough, to be again made to descend by cold. You see at once that this circulation would be maintained as long as the opposition of temperatures continues.

Now, I further reasoned in this way. If this be true, the bottom temperature of the South Atlantic will be lower than that of the North Atlantic, because the bottom temperature will depend upon the amount of glacial water which will flow along the floor of the great ocean. In the North Atlantic, that amount is limited by the narrowness and comparative restriction of the channels which I have described to you; while in the South Atlantic there is a free flow from the Antarctic area into the South Atlantic. You may therefore imagine the interest with which I looked at the returns of the "Challenger" when they first were sent home to our Admiralty. I found precisely what I expected. The accompanying section (Fig. 2) is not one given in the "Challenger" report, but it is one which I have constructed from their report. Their sections were taken in a sort of zigzag, for they passed four times across the Atlantic.

In constructing this diagram, I selected from the various temperature-soundings of the "Challenger," those which would best combine into a line passing nearly north and south, from 38° N. lat., through 22° N. lat., to the Equator, and thence through 7° S. lat., and 20° S. lat., to 38° S. lat.

The general temperature of the North Atlantic bottom was shown by numerous temperature-soundings to be about 35½° or 36°. It was nowhere found lower than that, except near Halifax. As they went north, towards the Polar channel, they got down to 35°; but they also got down to 35° and even 34° as they approached the Equator, near St. Thomas's. That was the first section which we received, and I said at once "There is the influence of the Antarctic flow." I quite expected that the Antarctic flow would extend to the north of the Equator, for it was so much more voluminous than the Arctic flow. Then when we got the South Atlantic sections, I saw at once that my surmise had been perfectly correct, for we then found that under the Equator we got the lowest temperature that we anywhere met with, viz., 32·4. The sections of the South Atlantic were taken at wide intervals, for the sea was very stormy at the time they crossed it. There was only one section made across the South Atlantic, and they did not hit upon the channel which brought in that water at 32·4°. There was no other section which was much below 34° or 33½°, but clearly, of course, that water came from the Antarctic. And what is most remarkable is the line of 35°, which can be clearly traced in the South Atlantic across the Equator, and then gradually slopes down in the North Atlantic till you lose it altogether.

Now that, I think, is as clear an indication as anything can be of this great under-flow of Polar water in the Atlantic,—the greater mass of polar water coming in from the Antarctic area, and the smaller mass of polar water coming from the Arctic area, which becomes diluted, as it were, by the water of the North Atlantic itself, so that the bottom temperature of the North Atlantic is higher, by about 3 degrees, than the temperature of the South Atlantic.

But the special point that I would have you dwell upon is this —that the isotherm of 40 degrees of temperature comes nearer to the surface under the Equator than it does anywhere else. At 22° N. lat., the line of 40 degrees lies at about 700 fathoms, and in 38° N. lat., the line of 40 degrees still lies at 650 fathoms. But from 22° N. lat. to the Equator there is a gradual ascent of this line of 40°, till under the Equator it comes to within 300 fathoms. Going down 300 fathoms, from a surface-temperature of 75°, you actually come down to a temperature of 40°. In the South Atlantic the line of 40°, though lying deeper than under the Equator, does not lie so deep as it does in the North Atlantic; and that it does not lie so deep there is, I believe, owing to the far larger mass of polar water which comes in from the Antarctic area, and the thinning out of the upper warm stratum as it moves from the Equator towards the South Pole, by the recession of its land-borders, whilst in the North Atlantic, by the approximation of its land-borders, it is pressed together laterally, and is therefore increased in thickness.

Now, you at once see why—on the doctrine I advocate—this cold water comes nearer to the surface under the Equator. It is because the warm surface water is continually being draughted off towards each Pole, while the cold water is rising up from below.

A very remarkable confirmation of that view is obtained from comparison of specific gravities. The density of surface water increases from the Polar area towards the Tropics; but the density of the bottom water remains very much the same at the tropics as at the polar areas; and that is just what you would expect if all this bottom water comes from the polar area. I am speaking now of salinity. You would expect that the bottom water should have the low salinity of the surface water of the poles. And so it has, we may say, speaking roughly, when the specific gravity is corrected for temperature. Of course, all such comparisons are made with reference to a uniform temperature. You may take your temperature to be what you please. Reduce it to 32°, or have it at 60°, or any other standard you like, so that you keep the same standard. Let us say that the specific gravity of Polar water brought to the standard of temperature is 1026. Well, the specific gravity of the surface water, in consequence of the evaporation to which it is subjected,—increasing, of course, with its approximation to the Equator,—is continually augmenting, we will say, to 1027. Putting aside fractional parts, there is just about that increase—from 1026 to 1027. But the salinity of the bottom water remains the same; and under the Tropics you bring up from the bottom water of 1026. You will ask, How is it that this underlies? Why, because it is heavier in consequence of its low temperature. The specific gravity that I am now speaking of is the comparative specific gravity of water all brought to the same temperature; but the actual specific gravity of the bottom water is greater, although its salinity is less, the reduction of its temperature more than compensating for its inferior salinity, and therefore it underlies the other.

But I wish now to impress upon you the curious fact that as you pass from either Tropic towards the Equator you find the specific gravity of the surface-water diminishing. This is a fact which was observed as long ago as Humboldt's voyages ; and the "Challenger" has found that the salinity of the surface-water under the Equator corresponds closely with that of the bottom-water. Thus while the mean of eight observations between Bermuda and St. Thomas's gave 1027·2 as the sp. gr. of surface-water, and 1026·3 as the sp. gr. of bottom-water, a mean of seventeen observations on surface-water in the Equatorial zone gave a sp. gr. of 1026·3, whilst eight observations on bottom-water gave a mean sp. gr. of 1026·1,—showing that the salinity of surface-water had fallen under the Equator to that of bottom (polar) water.

Now, taking that in connection with the influence of temperature I think you will see very clearly that the facts which I have stated with regard to temperature at once explain the constant rise of bottom water under the Equator towards the surface. Lenz was, to a certain degree, acquainted with these facts; and adduced the low salinity of equatorial surface water as evidence of the rise of polar water from the bottom. And Lenz pointed out from a great series of temperature observations, taken at from 200 to 300 or 400 fathoms' depth, that there is a cold band of water under the Equator, colder than any water to the north or the south of it; and upon that he framed a theory of ocean circulation, precisely corresponding to that to which my own observations have led me, and which I think you will see has been entirely confirmed by the result of the "Challenger" survey of the Atlantic.

Now, you will say, "What has this to do with animal life?" I believe it has everything to do with it ; and I will show you why. This ocean circulation brings every drop of water in turn to the surface. There is no other way in which the carbonic acid imparted by animal respiration and animal decomposition can be removed, and oxygen substituted, than the aëration of the water at the surface. You know perfectly well that even in our shallow aquariums it is necessary to have a constant agitation of the water to bring the water to the surface and expose it to the aërating influence of the atmosphere ; and the best provisions are those by which water is spirted up, a continual subdivision of it, as it were, being obtained by this movement, so as to get rid of the carbonic acid, and to allow it to take in a fresh supply of oxygen. We made gas analyses of the bottom water. I do not say these gas analyses were made in a manner altogether satisfactory. They were made according to the mode laid down for us by some of our best chemists. The water was boiled—subjected to prolonged ebullition; the gases were very carefully collected; and then they were examined chemically, and the percentages pretty accurately determined. The source of error lies in the extreme tenacity which sea water has for carbonic acid, but still the quantity retained would be pretty constant; and therefore we may say that, if the proportions that were got did not absolutely represent the percentages, yet the differences that I am about to state were just as good, and just as important and significant, as if we had obtained the actual percentages; just in the same manner as our first series of thermometric observations made with unprotected thermometers, which showed a difference of 13 degrees between the warm and the cold areas at corresponding depths, were just as good as later observations, although in the first case our actual temperatures were not accurate. We found in the subsequent years with our protected thermometers exactly the same *differences* of temperature, but our protected thermometers carried down the temperature about 3 degrees lower. So here, if we did not get all the carbonic acid, we still got all that could be obtained by boiling the water; and what remained was a certain fixed or constant quantity.

Now it is very remarkable that marine animals can live and move and have their being in an atmosphere containing 40 or 45 per cent. of carbonic acid. I have my doubts whether this carbonic acid does not exist in a liquid state diffused through the water, rather than in the gaseous state in which, as we know, it exerts its most prejudicial influence upon animal life. But still we had from 16 to 20 per cent. of oxygen; and as long as we had that amount of oxygen, the animals, I believe, got what they most wanted. That was our experience in all our own observations upon the gases of the deep sea area,—a series of observations taken off the coast of Ireland and the coast of Scotland, going down to depths of over 2,000 fathoms in some parts.

Now, when I went to the Mediterranean, I found an entirely different set of conditions. Knowing that the bottom temperature would probably be considerably higher, I fully expected to find a Tertiary fauna. We had previously, as you know, obtained a number of forms of animals corresponding to those of the Chalk.

The *Globigerinæ* we got up by the ton,—*Globigerina* mud which, when dried, could not be distinguished from chalk; and this contained siliceous sponges, which remind every geologist of the ventriculites of the Chalk, and a great many other Cretaceous forms. Going through the Mediterranean, which we knew to be a sea of the Tertiary period, I expected to find a Tertiary fauna over the whole of its bottom; and what was my disappointment—I say "my" because my friend Dr. Wyville Thompson could not accompany me on this cruise—what was my disappointment at bringing up a viscid mud not containing animals at all. We devoted a great deal of time and labour, and did not get even any minute Foraminifera. Taking this mud between our fingers, and working it, I found scarcely anything but fine impalpable particles that gave no indication of organic forms. A few little fragments we found now and then, very few indeed, and very small; but excepting near the Strait of Gibraltar, we got no living animals—I am speaking of the depths of the Mediterranean—save in shallow water. Now, the Mediterranean goes down in its western basin to 1600 fathoms, and in its eastern basin to 2000 fathoms, between Malta and Crete, for instance, and this depth extends a good way towards the Levant. The bottom temperature of the Mediterranean is uniform, or very nearly uniform, from 54° to 56°. And here, you see, is a marked contrast between the thermal condition of the Mediterranean, a sea almost as deep as the Atlantic, and that of the Atlantic itself.

Now, what is the reason of this? It is because this extraordinarily deep basin of the Mediterranean is cut off from the Atlantic by a shallow channel. If the Mediterranean area were elevated only 200 fathoms—1200 feet—it would be converted into two extremely deep lakes, inland seas, like the Caspian. It would be cut off entirely from the Atlantic at the western embouchure of the Strait of Gibraltar, the ridge line between Cape Spartel and Cape Trafalgar; and the two basins would be separated by the bank which connects Sicily and the coast of Tunis. Still these basins would be of immense depth. Deduct 200 fathoms from 1600 fathoms, and it leaves 1400. Deduct 200 from 2000, and it leaves 1800. Neither area would be much diminished by this elevation, because there is water of 200 fathoms' depth at a very small distance from land, on almost every part of this basin. What is the reason of this curious difference of temperature? Why, simply because the Mediterranean is cut off entirely from the influence of the polar underflow. Off Lisbon this underflow, taking the temperature of 40° as its limit, lies at a depth of more than 700 fathoms.

Comparing the thermal condition of the Mediterranean with that of the Atlantic, we find that whilst the surface-temperature of the Atlantic under the same parallels ranges in summer between 65° and 70°, that of the Mediterranean ranges between 70° and 80°. At the first hundred fathoms there is a drop down to 55°; but from this to the bottom, at whatever depth, there is no change at all. Below a stratum which is variable in temperature, the whole mass of the water is uniform in temperature; and this ranges down to 54°, 55°, or 56°, according to the latitude, being 56° in the eastern basin, 55° about Malta, and 54° towards Gibraltar.

We find this to agree with the mean winter temperature, or the isocheimal of the latitude; which, as shown by observations made at different points, gives 54°, 55°, and 56°, along that area of the Mediterranean. In the winter, the temperature from the surface to the bottom is equal: I do not mean to say within a degree, but close upon that. As soon as the atmosphere becomes warmer, the sun has more power. It shines upon the surface, and raises the temperature of the superficial layer, thereby producing increased evaporation. This evaporation, by rendering the superficial film more saline, increases its specific gravity; and it sinks down until its increased salinity is lost by diffusing itself through the water below. Practically we find that the surface heat is almost entirely limited to the first 50 fathoms; a little goes down to 100; and in the eastern basin, where the powerful action of the sun continues longer, I could trace it down to 200 fathoms; but the most powerful action is on the first 50 fathoms of the surface; and we may say practically that it scarcely reaches 100; and that from 100 fathoms downwards there is no difference in temperature whatever.

Now, then, what effect will this produce? Why, that the whole of the lower portion of the Mediterranean, below the influence of the Gibraltar current, which is limited to, we will say, 100 fathoms, is a stagnant pool. This, I take it, is the explanation of the absence of animal life upon the Mediterranean bottom. In my first year I was rather disposed to think it was the deposit of fine mud; and I do not say that this has not an influence. I found, as I mentioned to you, over the whole of the deep bottom of the Mediterranean, a deposit of fine mud gradually settling down, the particles being so fine that they would pass through the ordinary filtering paper. When I wanted to clear the specimens of bottom water for the determination of the salinity, I found it difficult to do so. I had to pass the water through the filter three or four times till the pores of the paper became clogged, so that it should stop these very fine particles, and allow the water to go through clear. That gives you an idea of the extreme fineness of this sediment, slowly, slowly settling down upon the bottom of the Mediterranean. Now, where does this come from? A portion is, no doubt, the result of the attrition of the waves upon the soft Tertiary strata which form the greater part of the shores of the Mediterranean; but the greater part, I believe, is the clay brought down by the two great rivers, the Rhone on the western basin, and the Nile on the east. The coarse particles brought down by these rivers are deposited near their mouths; but the fine particles, being suspended for a much longer period, are dispersed by surface-currents over the entire area, and gradually settle down to the bottom. This, no doubt, would be inimical to the presence of animal life. Those of you who have read Mr. Dana's book on Corals, will remember that he mentions that where clay is brought down by a river, and deposited on a coral bed, it kills the coral. And I believe that, generally speaking, this is found to be the case with regard to most forms of animal life, especially bivalve Mollusca. The fine mud, settling down upon their gills, clogs their filaments; so that they will not thrive in places where there is much of this silt deposited upon them.

But on thinking over the general application of this doctrine of thermal circulation to the case of the Mediterranean, I saw that there could be no thermal circulation in a sea in which the temperature is uniform from the top to the bottom, with only this exception, that the surface layer is heated during the summer and cooled during the winter. There will be nothing to send the cold water to the bottom, and there will be nothing to send the warm water to the top. In the next year, when I visited the Mediterranean again, I took out with me apparatus for gas analysis; and, though not very proficient in such work, I was able still to make comparative experiments that were sufficiently satisfactory, for I found that the proportion of carbonic acid, instead of being from 40 to 45 per cent. was from 60 to 65 per cent.; and the proportion of oxygen, instead of being from 16 to 20 per cent., was only about 5 per cent. The nitrogen was about the same as in the ocean.

You will see at once why this should be. The rivers bring down with the clay a large quantity of organic matter, and that organic matter uses up the oxygen and converts it into carbonic acid ; and in this manner the deep water of the Mediterranean becomes loaded with carbonic acid, and is correspondingly deprived of its oxygen. You will, therefore, I think, see at once why there must be a deficiency of animal life upon the bottom of this deep sea, and how it is that this general oceanic circulation of which I have spoken has an important influence—the most important, in my mind—in maintaining organic life upon the bottom. I was going to say to any depth; but I have been reading only this afternoon a paper by my friend Professor Wyville Thomson—the last communication he has made to the Royal Society—which gives a most curious qualification to that. It will appear that below a certain depth—about 2,200 fathoms, or it may be a little lower than that—there is a solvent power. I do not say that this is yet proved, but this is his belief from the character of the bottom at that great depth. Mr. Sorby has shown us how mechanical pressure will influence the solvent power of water. It is thought that at that great depth the water has a solvent power for the shells of *Globigerinæ*, no mass of *Globigerina* shells being found below a certain depth; but, on the other hand, there is first a *grey ooze*, and then there is a *red ooze* corresponding to greater depths. The grey ooze is at a greater depth than the *Globigerina* mud, and the red ooze is at a greater depth than the grey ooze; and it is Professor Thomson's belief that this solvent power of sea water at great depths causes it to act upon all organisms having calcareous matter as their skeletons, and that it may act also upon siliceous skeletons; but he believes, at any rate, that pressure does produce an influence upon animal life, not on account of any direct influence, but through its solvent power for calcareous matter.

There is another interesting observation contained in the same paper, which shows how extremely important all this careful examination of the sea bottom is to geologists. You know very well, no doubt, that Professor Ehrenberg first brought into view some years ago the fact that the green sands which occur in various geological formations mainly consist of the internal casts of Foraminifera; the body having been replaced by a deposit of silicates, and the shell having been subsequently dissolved away. It was first ascertained by the late Professor Bailey, of the United

States, that that very process is going on at the present time. He found in Foraminifera dredged up in the Gulf of Mexico exactly the same thing—that the cavities were occupied by glauconite, or some other green or ochreous silicate. In consequence of these observations, my friends, Professor Rupert Jones, and Mr. Parker, who had in their possession the dredgings of the late Professor Jukes upon the Australian coast, put these into acid, dissolved away the shell, and got out a series of the most wonderfully beautiful casts, which furnished the foundation of my own interpretation of the structure of *Eozöon*; because I look upon the peculiar structure of *Eozöon* as being due to a change of precisely the same character, namely, the replacement of its sarcodic body by a green silicate, usually serpentine—a silicate of magnesia. Now, I have obtained similar casts from elsewhere. The dredgings of Captain Spratt from the Ægean gave me a series of most beautiful casts, of a smaller size than those of Professor Jukes, but equally perfect. The observations recently made in the "Challenger" show that all along the line of the Agulhas current there is a green sand covering the bottom. Now, as Professor W. Thomson says, we should simply have noted this as green sand, if we had not had in our mind the observations of Professor Ehrenberg. Looking at this green sand with a microscope, we are able at once to recognise the grains as almost entirely the internal casts of Foraminifera. The question arises, however, how the shells were got rid of; you will see at once how it is, if they have lain on a bottom deep enough, supposing this doctrine is true. It will have to be tested; and I think the proper test will be to subject calcareous organisms to the pressure of the same hydraulic press which we have used for testing our thermometers, and to see whether sea water under this pressure will dissolve all calcareous structures. If it should do so, you at once see how these green sands have been formed. A process of chemical substitution—a process which I do not pretend to explain, but which all my friends amongst the most able chemists of this country agree with me in regarding in that light,—during the decay of the body of the animal, has effected a replacement, particle by particle, of the organic sarcode by these silicates. When that change has filled the chambers of these Foraminifera with these silicates, and the shells have been dissolved away by the solvent power of sea water under this tremendous pressure, there you have the green sand. If this view should be borne out by experiment—and I think it is experiment that is to determine it, and the experiment is tolerably easily made—I think you will say that this is one of the most beautiful applications of this kind of research to the explanation of geological phenomena that has ever been brought forward.

I have to apologise for having trespassed so long upon the time of this Association, but I do not think that I have said anything that can be regarded as superfluous; and it is difficult to convey a general doctrine of this kind, without laying one's foundation sufficiently over the whole area, as it were, that has to be covered. I might have gone into the history; I might have spent a good deal of time in telling you of my old friend Edward Forbes; but I must notice the one curious fact—the limitation to 300 fathoms which Forbes's work on the Ægean brought out, and which was supposed for a long time to dominate the life of the Ocean, is perfectly true of the Ægean. It is perfectly true of the whole of the Mediterranean in shallow water down to 250 fathoms. In our own researches we obtained exactly what Edward Forbes obtained—an abundant life in the littoral zone, a zone within 50 fathoms; a diminishing life down to 100 fathoms; a rapidly diminishing life from that down to 250 fathoms; and then a zero. Excepting for the vegetable *Nullipore*, which used to be called coralline, I should fix the zero, or the limit of life, in the Mediterranean at 250 fathoms; but then you will bear in mind that that limit, if my view is correct, is not a limit of pressure, or a limit of heat, or a limit even of food (though circulation will of course have the same effect in carrying down food, as in carrying down oxygen; it will carry down the surface food, that is, the organic matter which is produced by surface vegetation): the limit is mainly the limit of oxygenation. The thermal circulation is essential to the maintenance of oxygenation; and therefore the condition of an inland sea cut off from the great oceanic area is altogether different from that of the oceanic area; and any deposit that is being formed in an inland sea we may expect to be without any fossils, excepting those which represent the animal life of its shallower portions.

I may mention a confirmation of this view, which I have myself met with. You know that Malta is chiefly a calcareous formation—Middle Tertiary; a good deal of it—I believe most of it—Miocene and later; but it is almost entirely calcareous. Some of the calcareous beds contain quantities of fossils—Echinodermata, Mollusca, Corals—and these in a beautiful state of preservation. These beds are generally rather coarse. On the other hand, there are beds of very fine texture — texture so fine that it corresponds very closely indeed with the fine calcareous mud which I dredged up where it is least clayey. I could see at once that this fine mud varied a great deal in its composition; and on testing it with acids I could prove it at once. In some parts it was chiefly calcareous; in other parts it was aluminous—clayey. The very fine sandstone of Malta corresponds closely with the finest calcareous deposit of the Mediterranean. Now, this stone is used a good deal for building; but the finest beds of it, which occur in the island of Gozo, are used by the carvers who make the beautiful carvings that I dare say many of you have seen in this extremely fine "sandstone," as they call it. I asked the man who makes the largest carvings in Valetta, "Do you find any fossils in this stone?" "No, sir," he said, "nothing but sharks' teeth." I repeated the inquiry when I went the second time, the significance of this having occurred to me more strikingly. I got all the information I could from all those who had paid any attention to the geology of the island, and I received precisely the same answer—that the fossils are found in the comparatively coarse beds which are, I believe, the shallow water beds, and that this bed which is composed of the excessively fine "sandstone," as it is still called, though chiefly a calcareous deposit, contains no fossils but sharks' teeth. Now, of that you at once see the *rationale*. There is no life on the deep sea bottom, on which the finest particles slowly subside, and there are no fossils but those which would drop into it from above.

Now, of course, this view, if it is taken up by geologists, will have a most important influence upon geological inquiry, especially in its bearing upon a doctrine which my friend Professor Ramsay is well known to advocate. Certainly the extraordinary paucity of fossils in a very considerable number of strata, especially the Red Sandstones of inland seas—at least in many parts of those beds—does seem to correspond very closely with the facts which I have stated to you as to the absence of animal life upon the Mediterranean bottom. Of course everything will turn upon the depth of the communication between the inland sea and the ocean—whether the inland sea has any communication at all, and whether such communication is one of any depth. I might tell you of a number of cases which I have collected, where, by the comparison of temperature, I am able to say with considerable certainty what i the depth of the communication between the inland sea and th sea outside. I find the temperature going down to a certain poin the same as in the sea outside, and then continuing uniform to th bottom. Where that is the case, I believe I can say that the communication between the inland sea and the ocean outside stops jus at that point, and the depth at which we come upon the permanent temperature will correspond with the depth of the communication. It is so with the Mediterranean, and it is so in man other cases, so that of course the depth of the communicatio will have a great influence upon the degree in which the oceani circulation will penetrate, as it were, into the inland sea ; bu where the bottom to any considerable depth is cut off from th oceanic area, there, I will venture to say, we shall have a paucit of animal life. I do not say an absolute deficiency, because I hav reason to believe that in the Red Sea there may be a rich faun even on the deep bottom. You may ask why this should be, sinc the Red Sea is cut off from the Persian Gulf by the Straits of Babel Mandel, which are shallow. The reason of the difference betwee the condition of the Red Sea and the condition of the Mediterranean is that into the Red Sea no rivers discharge themselve The Red Sea has a rocky border, and there are no rivers to brin down the *débris* and organic matter of the land. The Red Se therefore, will be a very pure sea. There will be less stagnation at the bottom, as there is an agitation of the surface from th large amount of water that streams in owing to the enormou evaporation of the Red Sea, which has been estimated to b nearly 22 feet per annum, so that if the Straits of Babel-Mand were closed up, the Red Sea would be dry in two or three hundre years. I say, then, that with this large quantity of wat going in, and no organic matter being brought down by rivers t use up the oxygen, I can very well believe that there is quit enough movement of the water to carry down to the bottom sufficient supply of oxygen for the maintenance of animal life. do not think, therefore, that this would apply to the Red Sea; bu to a sea, such as the Caspian, into which great rivers discharg themselves, I believe that this would apply most completely; an I look forward with great interest to the time when these observations may be carried out, and these questions put to the test—the only sure test, the verification of actual conformity to fact.

SPECIAL GENERAL MEETING.

JANUARY 8TH, 1875.

A Requisition for a Special General Meeting of the Members of the Association for the purpose of considering and adopting amendments to the Laws, duly signed by twelve Members of the Association, having been presented to the General Committee by Mr. J. Logan Lobley and Mr. John Hopkinson, on the 4th December, 1874, a Special General Meeting of the Members of the Association was summoned in accordance with Law XXI., and held at University College, London, January 8th, 1875.

HENRY WOODWARD, Esq., F.R.S., &c., President, in the Chair.

Amendments to Laws VIII., IX., XV., XVIII., XXII. and XXIV. were carried, and the Laws as amended were duly passed.

These Laws as they previously stood and as amended, printed in contiguous columns, are subjoined.

LAW VIII.

PREVIOUS TO AMENDMENT.	AS AMENDED.
That the Method of voting for the election of Members be by show of hands, unless a ballot shall have been previously demanded.	That the method of voting for the election of Members be by ballot.

LAW IX.

That the negative votes of one-sixth of the Members present exclude a Candidate.	That the negative votes of one-sixth of the Members voting exclude a Candidate.

LAW XV.

That the management of the Association be vested in a President, four Vice-Presidents, a Treasurer, an Honorary Secretary, an Honorary Librarian, and twelve other Members, who shall constitute a General Committee, to be elected annually, by ballot if required; the retiring officers being eligible for re-election.	That the management of the Association be vested in a President, four Vice-Presidents, a Treasurer, an Honorary Secretary, an Honorary Librarian, and twelve other Members, who shall constitute a General Committee, to be elected annually at the Annual General Meeting by ballot; the senior Vice-President and the two Senior Members of the General Committee, who shall not have held, during the preceding year, any other office, shall not be eligible for re-election to their respective offices until the next Annual General Meeting.

	PREVIOUS TO AMENDMENT.	AS AMENDED.
LAW XVIII.	That for the purpose of the legal protection of the property of the Association, all the funds, books, and other property of the Association be declared to be vested in three or more Members of the Association, to be appointed by the General Committee; but the General Committee shall have power, by the vote of a majority of its whole number, to sell or otherwise dispose of any duplicate specimens, books, or other property which it may not seem to them advisable to retain.	That for the purpose of the legal protection of the property of the Association, all the funds, books, and other property of the Association be declared to be vested in three or more Trustees, who shall be Members of the Association, to be appointed by the General Committee; but the General Committee shall have power, by the vote of a majority of its whole number, to sell or otherwise dispose of, any duplicate specimens, books, or other property which it may not seem to them advisable to retain.
LAW XXII.	That the accounts of the Association shall be made up to the 31st December in each year, and audited by two Auditors, who shall be appointed at the Ordinary Meeting following; and the balance-sheet shall be submitted, together with a Report of the general progress of the Association during the preceding year to an Annual Meeting, which shall be held at such hour before the first Ordinary Meeting in February as the General Committee shall appoint.	That the accounts of the Association shall be made up to the 31st December in each year, and audited by two Auditors, who shall be appointed at the Ordinary Meeting following; and the balance-sheet shall be submitted, together with a Report of the general progress of the Association during the preceding year to an Annual General Meeting, which shall be held at such hour before the first Ordinary Meeting in February as the General Committee shall appoint.
LAW XXIV.	That gentlemen of eminence in geological science, or who have done some special service to the Association, may be recommended by the General Committee for election as Honorary Members at the Annual Meeting, and shall upon being elected have full privileges of membership, but that the number of Honorary Members shall not exceed twenty.	That gentlemen of eminence in geological science, or who have done some special service to the Association, may be recommended by the General Committee for election as Honorary Members at the Annual General Meeting, and shall, upon being elected, have full privileges of membership, but that the number of Honorary Members shall not exceed twenty.

The thanks of the meeting were unanimously given to the President for his able and impartial conduct in the chair, and the Special General Meeting then terminated.

ANNUAL GENERAL MEETING.

February 5th, 1875.

Robert Etheridge, Esq., F.R.S., F.G.S., &c., Vice-President, in the Chair.

The following Report was read by the Honorary Secretary:—

REPORT OF THE GENERAL COMMITTEE FOR 1874.

The General Committee have much pleasure in congratulating the Association upon the results of the past year.

A considerable number of new Members have been added to the list, and several of these are already well known throughout the country, by their study and practice of Geological Science. There have been a few losses by death, and, if the number of those who have retired is somewhat more numerous than has been the case of later years, they consisted, with few exceptions, of Members whose interest in the proceedings of the Association was never very ardent.

Members elected during 1874 . . .	49
Withdrawals 14, Deaths 4	18
Increase	31

The Census of the Association on the 1st January, 1875, gave the following results:—

Honorary Members	12
Life Members	42
Old Country Members	28
Other Members	257
	339

The lamented death of Professor Phillips, reduces the number of Honorary Members to 12. A short notice of the sad occurrence, which deprived the Association of one amongst the most eminent of its body, will be found in the forthcoming number of Vol. iv. of the "Proceedings."

The financial position of the Association is very satisfactory, and the large number of Members now contributing has yielded a sum which amply provides for an increased expenditure, the benefits of which are shared by all. At the same time the Committee venture to suggest the importance of punctuality in the payment of subscriptions, as the smallness of the sum due from each makes it all the more necessary that it should be paid within the current year. A sum of £15 15s. 0d., being the amount of the Life Compositions for the year 1874, has been invested in Consols.

During the year 1874, the Editor has brought out five numbers of the "Proceedings," completing Vol. iii. Your Committee believe that few other societies give more to their members, by way of publications, in proportion to the very moderate amount at which the subscription is fixed. At the same time your Committee are aware of the great importance of bringing up the publications of Proceedings to a level, in point of time, with the reading of Papers, and the reporting of Excursions, as they feel that much good matter may be withheld from the Association, in consequence of the long time that elapses before an author can hope to see his work in print. It is also equally certain, that the interest in an excursion very often dies away before any record of it appears in the publications of the Association. It is true that some of the larger excursions of the past year have been reported with considerable fulness in the provincial papers, and also, by the kindness of the Editor of the Geological Magazine, have been noticed in its pages, but your Committee hope the time is not far distant when the finances of the Association will permit of an earlier publication of the "Proceedings."

The Papers read at the evening meetings, have been fully equal to the average of previous years; and as the meetings are generally well attended, there has been a considerable amount of discussion provoked. An interesting Lecture, by your President, on the "Dawn and Development of Life on the Earth," well illustrated by How's Geological Photographs, attracted a large audience. The last meeting of the year was ably occupied by Dr. Carpenter, in showing the important bearing of the doctrine of a Thermal Oceanic Circulation upon Geological Studies. The President also repeated the practice, so happily commenced by him of delivering an Inaugural Address on the opening of the Session 1874-5.

List of Papers and Lectures read, or delivered, during the year 1874:—

On the Nature and Origin of Flint and Allied Bodies, by M. HAWKINS JOHNSON, F.G.S.

On the Probability of Finding Coal in the Eastern Counties, by JOHN GUNN, F.G.S.

On the Geology of the Neighbourhood of Nottingham, by the Rev. ALEXANDER IRVING, B.A., B. Sc., F.G.S.

On the Dawn and Development of Life on the Earth, by the PRESIDENT.

Observations on some Carboniferous Polyzoa, by R. ETHERIDGE, Junr., F.G.S.

On some Geological Puzzles, by EDWARD CHARLESWORTH, F.G.S.

On the Lower Greensand and Gault in the Neighbourhood of Folkestone, by F. G. H. PRICE, F.G.S., M.A.I.

On a Collection of Fossils, from the Upper Greensand of Marden, Cambs., by H. GEORGE FORDHAM, F.G.S.

On Deposits Forming in the British Seas, by G. A. LEBOUR, F.G.S., F.R.G.S., &c.

Address at the Opening of the Session 1874—1875, by the PRESIDENT.

Lecture on the Conditions which determine the Presence or Absence of Animal Life on the Deep Sea Bottom, by Dr. W. B. CARPENTER, F.R.S.

During the year 1874 the following Museums and Collections were inspected:—

British Museum—Mineral Collection—Professor MASKELYNE.

" " Fossil Mollusca—Mr. H. WOODWARD.

Oxford Museum—Professor PHILLIPS.

Collection of Fossils from the Northampton Sand (Inferior Oolite), Lincolnshire Limestone (Inferior Oolite), and Great Oolite, Mr. SHARP.

Collection of Tertiary and Cretaceous Fossils—Mr. CALEB EVANS.

Collection of Lias Fossils—Rev. M. SMITHE.

Collection of Extinct Mammalia—Miss STRICKLAND.

The Excursions of the Association have been fairly attended by Members and their friends. Subjoined is a list of the Excursions for 1874, arranged in the order of the formations visited.

FORMATION.	LOCALITIES.	DATES.	PRINCIPAL DIRECTORS.
Post Glacial	Oxford, Grays, Hampstead, St. Mary's Cray, Well Hill, Tewkesbury Park	April 6, May 16, June 22, 27, July 24	Professor Phillips, Mr. Hy. Walker, Professor Prestwich, Dr. Wright.
Bagshot Sands	Hampstead	June 22	Mr. Caleb Evans.
London Clay	Lewisham, Hampstead	April 25, June 22	Mr. Whitaker, Mr. Caleb Evans.
Woolwich and Reading Beds	Lewisham, St. Mary's Cray	April 25, June 27	Mr. Whitaker, Professor Hughes.
Thanet Sands	Lewisham, St. Mary's Cray	April 25, June 27	Mr. Whitaker, Professor Hughes.
Chalk	Lewisham, Grays, Caterham, Shoreham	April 25, May 16, June 13, 27	Professor Morris, Mr. Hy. Walker, Mr. Lobley, Professor Prestwich.
Upper Greensand	Godstone	June 13	Mr. Lobley.
Lower Greensand	Tilburstow, Nutfield	June 13	Mr. Lobley.
Wealden	Shotover	April 6	Professor Phillips, Mr Parker.
Portlandian	Shotover	April 6	Professor Phillips, Mr Parker.
Kim. Clay	Shotover	April 6	Professor Phillips, Mr Parker.
Corallian	Heddington, Shotover	April 6	Professor Phillips, Mr Parker.
Oxford Clay	Oxford	April 6	Professor Phillips, Mr Parker.
Cornbrash	Hardborough, Stamford-field	April 7, May 26	Mr. Parker, Mr. Sharp.
Great (Bath) Oolite	Stonesfield, Blisworth, Kingsthorpe, Stamford-field	April 7, May 25, 26	Mr. Parker, Mr. Sharp.
Inferior Oolite	Charlbury, Northampton, Stamford, Collyweston, Leckhampton	April 7, May 25, 26, July 21	Professor Phillips, Mr. Sharp, Dr. Wright.
Upper and Middle Lias	Charlbury, Northampton, Churchdown, Leckhampton	April 7, May 25, July 20, 21	Professor Phillips, Mr. Sharp, Dr. Wright.
Lower Lias	Cheltenham, Frethern, Tewkesbury Park	July 23, 24	Mr. Lucy, Dr. Wright.
Rhœtic	Garden Cliff, Coombe Hill	July 23, 24	Mr. Lucy, Dr. Wright.
Ludlow	May Hill	July 22	Mr. Lobley.
Wenlock and Woolhope Beds	May Hill	July 22	Mr. Lobley.
Upper Llandovery	May Hill	July 22	Mr. Lobley.

The thanks of the Association for assistance or hospitality rendered on the above mentioned Excursions and Visits are especially due to the authorities of the British Museum; the late Professor Phillips, F.R.S.; Mr. James Parker, F.G.S., Oxford; Mr. W. Whitaker, B.A., F.G.S., Geological Survey; Mr. Samuel Sharp, F.S.A., F.G.S., Dallington Hall, Northampton; Mr. Caleb Evans, F.G.S., Hampstead; Professor Prestwich, F.R.S., Shoreham; Dr. Wright, F.G.S., Cheltenham; Mr. Lucy, F.G.S., Gloucester; Rev. W. S. Symonds, M.A., F.G.S., Pendock; and Miss Strickland, Apperley Court.

The Library of the Geologists' Association still continues to do good service by circulating standard Geological Works among the Members. The number of books issued during the year shows a slight decrease upon those issued in the preceding Session, but this may be attributed to the fact that one of the meetings was held in a lecture room in the College, where the Library of the Association was consequently inaccessible to Members.

The additions by purchase to the Library have already been notified by circular, and the new Catalogue will show those that have been added through the generosity of Authors.

The Librarian thinks that the Library should, and he hopes shortly will, be used more extensively by Members. He desires to point out that about 75 per cent. of books issued are of the more popular class, and consist chiefly of text-books, and the works of well known Authors; while the remaining 25 per cent. only, are those of the "Proceedings of Societies," and others of a more special character. He thinks it matter for regret that a greater number of the latter kind are not made use of for purposes of research. He would also observe that not more than one-fourth of the average number of Members attending the meetings avail themselves of the use of the Library at all.

In accordance with the usual custom, Mr. Henry Woodward, F.R.S., having filled the Presidential Chair during two years, now retires from the post. It is almost unnecessary to point out the great advantages which have accrued to the Association from its connection with a gentleman such as the retiring President. Although largely occupied with the business of an important public department, and suffering still further demands upon his time as Editor of the "Geological Magazine," Mr. Woodward has always contrived to find leisure to attend with the utmost exactitude to the affairs of the Association, both in Committee and at the Meetings. He has inaugurated the system, which it is to be hoped may be followed, of delivering an Address at the opening of the Session. On each of these occasions there was a large and attentive audience. Your Committee confidently recommend him for election as an Honorary Member of the Geologists' Association, feeling sure that Members generally will be glad of this opportunity of testifying their regard for one to whom they owe so much. They also recommend Mr. William Whitaker, of the Geological Survey, for election as an Honorary Member.

Your Committee have much pleasure in proposing, as Mr. Woodward's successor, William Carruthers, Esq., F.R.S., F.Z.S., F.G.S., keeper of the Botanical Department in the British Museum, a gentleman who has on several occasions placed his services at the disposal of the Association, and who is well known in the scientific world as the leading authority on Fossil Botany, and also as a most able naturalist and palæontologist. Your Committee have full confidence that Mr. Carruthers will aid in maintaining, as your President, the high character and efficiency of the Association which it has gained for itself during the terms of office of Mr. Woodward, Professor Morris, Mr. Wiltshire, and other past Presidents of the Society.

Mr. S. R. Pattison, who so kindly undertook about eighteen months ago, at very short notice, the office of Treasurer, finds that the pressure of professional work compels him to resign his post. This circumstance your Committee much regret.

As his successor your Committee have great pleasure in nominating Mr. F. G. H. Price, whose business abilities and connection with the well-known bankers, Messrs. Child and Co., of No. 1, Temple Bar, point him out as a suitable person to be entrusted with the duties of Treasurer. Your Committee feel sure that this appointment, if confirmed, will be conducive to the financial welfare of the Association.

Your Committee again desire to offer your best thanks to the authorities of University College for the privilege you enjoy of meeting in this beautiful Hall, as well as for the courtesy with which the wishes of the Committee are acceded to.

BALANCE SHEET OF RECEIPTS AND DISBURSEMENTS

For the Year ending December 31st, 1874.

Dr.

	£ s. d.	£ s. d.
By Balance, January 1st, 1874		136 6 3
,, Admission Fees	21 10 0	
,, Annual Subscriptions	98 4 0	
		119 14 0
,, Life Compositions		15 15 0
,, Sale of Publications		1 0 0
,, Dividend on £126 16s. 4d.		3 16 0
		£276 11 3

Cr.

	£ s. d.
To Printing and illustrating "Proceedings"	73 4 6
,, Miscellaneous Printing, including the "Report"	25 1 3
,, Library	7 14 0
,, Reporting...	3 3 0
,, Gas and Attendance	8 7 6
,, Postage, Stationery, &c.	30 9 2
Bought £16 18s. 3d. Consols	15 15 0
Balance	112 16 10
	£276 11 3

We have this day examined the Accounts of the Geologists' Association, and we find that, according to the accounts laid before us, a sum of £48 7s. 3d. remained in the hands of the Treasurer on the 31st December, 1874, and a sum of £64 9s. 7d. remained in the hands of the late Treasurer at the same date, making together a balance of £112 16s. 10d. due to the Association on the 31st December, 1874.

G. STALEY MOSSE,
J. SLADE, F.G.S., } *Auditors.*

January 19*th*, 1875.

Beyond the amount of £98 4s. received for Annual Subscriptions during the year 1874, a further sum of £31 10s. is due to the Association for Subscriptions remaining unpaid on the 31st December, 1874.

The Report of the General Committee was unanimously adopted as the Annual Report of the Association for 1874.

Henry Woodward, Esq., F.R.S., F.G.S., F.Z.S., and William Whitaker, Esq., B.A., F.G.S. of Her Majesty's Geological Survey, were duly elected Honorary Members of the Association.

OFFICERS AND GENERAL COMMITTEE,

Elected at the Annual General Meeting of the Association, held at University College February 5th, 1875 :—

PRESIDENT.

William Carruthers, Esq., F.R.S., F.L.S., F.G.S.

VICE-PRESIDENTS.

Robert Etheridge, Esq., F.R.S., F.R.S.E., F.G.S., &c.
Prof. T. Rupert Jones, F.R.S., F.G.S.
J. Logan Lobley, Esq., F.G.S., F.R.G.S.
Henry Woodward, Esq., F.R.S., F.G.S.

TREASURER.

F. G. Hilton Price, Esq., F.G.S., F.R.G.S., M.A.I.

HONORARY SECRETARY.

Wilfrid H. Hudleston, Esq., M.A., F.G.S., F.C.S., &c.

HONORARY LIBRARIAN.

John A. Coombs, Esq., F.G.S.

GENERAL COMMITTEE.

William Carruthers, Esq., F.R.S., F.L.S., F.G.S.
Frank Clarkson, Esq., F.G.S.
John A. Coombs, Esq., F.G.S.
Robert Etheridge, Esq., F.R.S., F.R.S.E., F.G.S., &c.
John Foulerton, Esq., M.D., F.R.S.E.
Captain Marshall Hall, F.G.S., F.C.S.
Henry Hicks, Esq., F.G.S., F.R.C.S.
John Hopkinson, Esq., F.G.S., F.R.M.S.
Wilfrid H. Hudleston, Esq., M.A., F.C.S., &c.
James William Ilott, Esq.
Matthew Hawkins Johnson, Esq., F.G.S.
Prof. T. Rupert Jones, F.R.S., F.G.S., &c.
W. H. Leighton, Esq., F.G.S.
J. Logan Lobley, Esq., F.G.S., F.R.G.S.
John East Hunter Peyton, Esq., F.G.S., F.R.A.S.
John S. Phené, Esq., LL.D., F.S.A., F.G.S., &c.
F. G. Hilton Price, Esq., F.G.S., F.R.G.S., M.A.I.
F. W. Rudler, Esq., F.G.S., M.A.I.
Jeremiah Slade, Esq., F.G.S.
Henry Woodward, Esq., F.R.S., F.G.S., &c.

The Thanks of the Association were given to the late President, and to the other Officers of the Association for the past year, for their services, and the Annual General Meeting then terminated.

ORDINARY MEETING, FEBRUARY, 5TH, 1875.

WILLIAM CARRUTHERS, Esq., F.R.S., F.L.S., F.G.S., President, in the Chair.

The following Donations were announced :—

"Bristol Naturalist's Society Proceedings," Vol. 1., part i.; from that Society.

"Leeds Philosophical and Literary Society : Annual Reports," 1866-67, 1870-71.

"Quarterly Journal of the Geological Society of London," Vol. xxx., part 5; from that Society.

"Abstracts of Proceedings of the Geological Society ;" from that Society.

"Proceedings of the Literary and Philosophical Society of Liverpool," Vol. xxviii. (1873-4) ; from that Society.

"Proceedings of the Yorkshire Philosophical Society," 1873; from that Society.

"Annual Report of the Leeds Philosophical and Literary Society," 1866-7; from that Society.

"Transactions of the Geological Society of Glasgow," Vol. iv., part 2; from that Society.

"Transactions of the Royal Irish Academy," Vol. xxv., parts 1, 2, 3, 4, 16, 17 ; from that Academy.

"Proceedings of the Royal Irish Academy," Vol. i., Series ii., Nos. 2, 3, 4, 5, 6, 7, 8 ; from that Academy.

"Journal of the Society of Arts," Dec. 1874 and Jan. 1875; from that Society.

"Proceedings and Transactions of the Nova Scotian Institute of Natural Science." Vol. iii., part 4; from that Institute.

"The Natural History and Classification of Quadrupeds," by William Swainson; from John Hopkinson, Esq., F.G.S.

"The Old Glaciers of Switzerland and North Wales," by A. C. Ramsay, F.R.S., F.G.S.; from John Hopkinson, Esq., F.G.S.

"The Cotteswold Hills," by John Lycett, F.G.S; from Professor J. Tennant, F.G.S.

"West Indian Tertiary Fossils," by R. J. L. Guppy, F.G.S.; from the Author.

"British Camps and British Temples," by John S. Phené, Esq., F.G. S., F.S.A.; from the Author.

"On the Causes of Art," by John S. Phené, Esq., F.G.S., F.S.A.; from the Author.

"The Colossal Sculptures of the Celts in Sussex," by John S. Phené, Esq., F.G.S., F.S.A.; from the Author.

The following were elected Members of the Association:—

William Nuttall, Esq.; J. M. Black, Esq., F.G.S.; Charles Campbell, Esq.; and B. Winstone, Esq., M.R.C.S.

The following Paper was read:—

ON THE VOLCANIC GEOLOGY OF ICELAND.

By WILLIAM LORD WATTS, ESQ.

(Abstract.)

Iceland is still a *terra incognita* as regards its physical geology and geography, so large a part of it still remaining unvisited. The accompanying notes, which I have made during my visits to a portion of those hitherto untrodden districts, may contribute to a knowledge of the region, and of the vastness of the volcanic eruptions which have produced the present contour of a part of its surface.

Volcanic phenomena in Iceland appear, with some few exceptions, to coincide exactly with those of other parts of the world.

There are three aspects from which volcanic rocks can be viewed. Firstly as regards the phenomena of their production. Secondly, with respect to their geological age, and their effect upon adjacent sedementary rocks. Thirdly, as mineralogical compounds, and their similarity to and difference from the products of volcanoes of other localities or periods.

In the parts of Iceland that I have traversed, however, the first and third aspects are unfortunately the only ones in which it is practicable to study volcanic products, for all the rocks I have met with in that country are either igneous in their origin or derivations from igneous rocks.

Iceland lies almost at the northern extremity of the great volcanic line which skirts the extreme west of the Old World. This line extends from Jan Mayan through Iceland, the Faröes, Great Britain, the Madeiras, the Azores, Cape de Verdes, the Canaries, and breaking out along the West Coast of Africa, terminates at Tristan da Cunha.

Though not more than one-third larger than Ireland, it contains more than 20 mountains which have been witnessed in actual eruption during historic periods, and its only parallel as a centre of volcanic activity must be sought upon the eastern or western shores of the Pacific Ocean. Along the coast there is great evidence of elevation, raised beaches and sea-worn caves occurring in some instances miles from the present coast-line, though I am inclined to think that they belong to a very remote period, for I have been unable to learn that there has been any variation in the soundings along the coast during historic times.

Upon landing at the capital of Iceland, Reykjavick, the contour of the country at once proclaims its volcanic character. The town of Reickjavick itself stands upon the borders of an ancient basaltic lava stream. Similar streams traverse the surrounding country in many directions, though direct volcanic activity for some centuries appears to have subsided in this section of the island, merely proclaiming its former existence by secondary symptoms, such as hot springs and solfataras. The former occur near Reykiness, the capital Reykjavick, and Rekil, from which circumstance those places derive their names—Rekil being the Icelandic for the verb "to smoke;" while the latter are at Krisuvick, a day's journey to the south-east of Reykjavick. There are 80 or 90 of the solfataras, and they occur in a mountain of decomposed palagonite tuff, the sides of which are covered with fragmentary matter in all stages of decomposition, together with the products of the various gaseous emanations. The solfataras themselves are mere pits of siliceous and calcareous bluish-white mud, the result of the decomposition of contiguous tuff. This mud is of a very high temperature, and in many places in a violent state of ebullition, the principal gas exhaled being sulphuretted hydrogen, depositing great quantities of sulphur upon the surface, in crusts varying from an inch to a foot or more in thickness. The thicker crusts are very impure specimens of sulphur, being mixed with a considerable quantity of carbonate or of sulphate of lime.

The road from Reykjavick to Great Geysir runs through the far-famed Thingvalla, the chief geological features of which are the two large rifts in the lava, namely, Almanna Gjà to the west, and Rafvens Rift to the east. The largest of these is the Almanna Gjà, which is 7 or 8 miles long, 100 feet wide, and in some places 200 feet deep. A very superficial glance at the valley and these rifts—more especially when they are compared with similar phenomena which occur in many other places on a smaller scale—at once explains their origin.

A large river of lava at some remote period entered the northern end of the valley, and nearly covered the whole of the depression, a thick crust soon formed over the surface of the stream, and when the supply ceased, the still liquid lava at the bottom of the stream flowed from beneath the crust into the deeper portions of the lake, which occupies a considerable area in the valley, leaving the unsupported crust to sink down in the middle, thus occasioning these large lateral cracks upon either side of the stream.

Professor Forbes calculated the age of Great Geysir, from the thickness of the siliceous sinter which surrounds its basin, at about 1000 years. There are numerous hot springs throughout the Island which owe their existence to earthquakes, which instantaneously called them into being. In 1339 a hot spring 60 feet in diameter suddenly appeared at Mosfelc, and during the earthquakes which preceded the great eruption of Skaptar in 1783, no fewer than thirty-five new hot springs made their appearance. The Great Geysir is surrounded by numerous other springs of all temperatures and sizes, whose deposits vary according to the character of the rocks through which they pass.

The most important geological features of Iceland are its volcanoes and their products. The traveller approaches Hecla from the N.W., his road lying across a plain which the eruptions of Hecla have from time to time desolated. As the mountain is approached from the N.W. its form appears to be that of an oblong cone. It is about twenty miles in circumference and 5000 feet in height, and is capped by three smaller cones, the product of more recent eruptions. Its craters are all upon the W. and S.W. sides, and most of the lava streams have flowed in the same direction. It has been in eruption no less than fourteen times since 1004. The ascent of the mountain really commences at 800 feet, where the climber passes the termination of an arm of the latest lava stream, the surface of this arm being very rough, and covered with masses of scoriæ; though masses of compact lava appear to have welled up through many interstices in the crust.

We ascended by the side of the lava stream over an undulating sandy slope, and, passing a fine specimen of a cinder cone upon our right, we left our horses; and clambering over the rugged surface of the latest lava stream and flanking the lava, we commenced the ascent of the Ash and Cinder Cone, which forms the summit of the mountain. We now passed several masses of a grey stony variety of lava, but upon re-meeting this lava, at the height of 3,600 feet, the stream appeared to be very thin, and had cooled upon this steep incline in masses, passing almost into an obsidian. Further on the lava became of a more cindery nature. All the Hecla lavas that I have seen are basaltic or doleritic, and contain crystals of felspar and olivine. We were soon at the edge of the crater of 1846, as it is erroneously called. It is simply a circular opening, which topped a larger and more distant crater, from which, I believe, the eruption proceeded. This smaller collateral orifice was perfectly cold, but from the larger one steamy exhalations were rising. This larger crater was an elliptical depression about 300 yards across and 250 feet deep ; its sides consisted of a series of terraced banks of many-coloured cinders, and of sulphurous clay. At the bottom was a little patch of indurated snow. Descending I found in some places the ashes and clay were too hot for the hand to bear, and wreaths of vapour were rising from amongst them, depositing a variety of sublimations upon their surfaces. Re-ascending and proceeding along a narrow saddle of the mountain, its two principal cones came into view. Crossing a snow slope which contained many miniature ice caverns, we ascended to the apex of the mountain, which surrounds a long, deep crater, breached towards the west, and nearly choked with snow. From one part of it a small body of vapour was rising. Upon the W. of the third cone we were informed that there was a fourth crater.

Two or three days' journey from Hecla brings us to the foot of Myrdals Jökull, which includes the much-dreaded volcano Katlugia. The hills immediately around Myrdals Jökull are mostly composed of palagonitic agglomerate, which encloses numerous fragments of basalt, many of which appear to have been subjected to the action of fire. A great deal of this agglomerate is doubtless formed by the huge debacles of mud and water that from time to time have rushed down the sides of these mountains into the plains beneath, caused either by the bursting of the basins of crater lakes or the sudden melting of the frozen covering of the volcanic heights. These have poured in a torrent of mud and ashes down the sides of the mountains, gathering up the pulverulent volcanic materials and other accumulations which they met with in their courses, and mingling together the aqueous and igneous ejectamenta in the most extraordinary confusion, have hurled themselves in heterogeneous avalanches upon the lower elevations, forming banks of muddy agglomerate upon the plains, and filling the depressions in some instances with seething paste.

But some of these tuffs are formed without the terrible phenomena just described; the gentle and continual wash of the mountain streams have accomplished as much as the overwhelming debacle, bringing down atom by atom the volcanic ejectments, the constituents of disintegrating rocks, and piece by piece the fragments of basalt; yes, even in the very abode of convulsion do we find the constant and gentle forces of nature vieing with the terrible. In one corner amongst the hills, filling a depression, I found beds of black and almost impalpable sand, which perhaps were originated by the wind carrying the light volcanic dust (probably strewn over the country by the eruption of some neighbouring volcano) into the position in which I found it. Indeed we see the same thing going on every day upon the large sandy plains to the east of Myrdals Jökull. Having ascended the hills below Myrdals Jökull, on our way to Katlugia, we will glance back at the history of this terrible volcano, which has been in eruption no less than 15 times since the year 900.

The principal phenomena attending the eruptions of this volcano are stupendous floods of heated water and the prodigious quantities of sand ejected. It has, I believe, never been known to produce lava; but upon the base of the mountain I found numerous ancient lavas, proving that Myrdals Jökull at one time was no exception to its neighbouring volcanoes. These lavas are mostly felsitic, and some of them, despite their porous nature, are almost obsidians. The floods from Katlugia during eruptions have often submerged a district of 280 square miles, continuing sometimes for days in spite of the rapid outflow to the sea. These floods are produced not only by the sudden melting of the snow on the Jokull at the time of eruptions, but in all probability by the bursting of large cavities in and underneath the mountain in which water might have been for years accumulating. This aqueous phenomenon is, however, by no means peculiar to Katlugia, although it occurs there upon much the larger scale, for during the 13th and 14th centuries all the volcanoes in the south of Iceland erupted water.

But to return to Katlugia. Upon the base of the mountain I encountered some masses of compact basalt that split with the hammer into thin laminæ, presenting the conchoidal fracture of a flint. The rocks, a short distance from the glacier, were much scratched and furrowed by glacial action, and I found two or three large masses of ferruginous lava many tons in weight, that when struck with a hammer sounded perfectly hollow, doubtless owing to their cellular nature, the multiplied echoes from the numerous small cavities producing a precisely similar effect to that produced by one large cavity, as pointed out by Mr. Scrope in relation to the solfataras of the Italian volcanoes.

Upon the S.E. side of the Jökull, in a line with the mountain Aruna-stakka, is a black cone of volcanic sand and ash, with a base of tuff protruding. through the ice which, upon closer inspection, proved to enclose a perfectly formed crater about 300 feet in diameter. This crater was reached towards the S.E. At the bottom was a deep pool of turbid water, into which several small streams emptied themselves, but none ran out, this is possibly one of the reservoirs in which the dreaded waters of Katlugia accumulated in the bowels of the mountain. Standing at the summit of this cone the eye wanders over a vast accumulation of *débris* and sandy moraine which is borne by the blackened ice of the glaciers towards the broad dark sandy waste of Myrdals Sandr from a horseshoe-shaped valley which leads right into the heart of Myrdals Jökull. This valley, which is filled with an immense glacier, is surrounded by steep banks and slopes of indurated snow, from which protrude several cliffs of felstone and banks of sand. It is none other than the barren crater Katlugia. Upon exploring it we found in one or two places considerable depressions partially filled with water. The only indications of its destructive nature were the black desolate plain of sand to the east and the inky waves of the discoloured glacier below us.

Leaving Katlugia, we cross Myrdals Sandr (the greater part of which has been erupted by Katlugia), and pause for a few moments beside the huge lava stream of Skaptar which flowed from Skaptar Jökull (the S.W. corner of Vatna Jökull) during the memorable eruption of 1783. This produced two streams, one 50 miles long and 15 wide, and the other 40 miles in length and seven broad, being in some places 500 feet in depth. It has been computed that the entire mass exceeds in bulk that of Mont Blanc.

This lava is highly ferruginous, and strongly impregnates the waters of the river Eldvatn which flows through it.

To the Vatna Jökull (of which Skaptar Jökull is but a small part), together with the unknown country which lies immediately to the north of it, the volcanic forces of Iceland seem at present to have retreated. The Vatna Jökull is a tract of ice and snow which rests upon a nest of volcanoes, many of which have been in erruption during historic times; the peaks of many of these protruding through the frozen covering. The Vatna rises from a series of basaltic terraces to a large " rolling" snow-covered plateau 5,950 feet above sea level.

While investigating this remarkable district last year I came upon a cluster of conical eminences which rise from a larger pit or crater upon the mountain. This showed a complete transition from highly vitreous obsidian to a banded semi-obsidian then to a pearlite which again passed into a grey stoney variety of lava which so much resembles the alum stones of Hungary. Upon the unexplored north of the Vatna Jökull I believe there may be permanently active volcanoes, for, from time to time, eruptions have been witnessed in that direction, and yet no one has penetrated to where they occur. Gaseous emanations, that I am sure cannot come from anything but a body of cooling lava, are frequently experienced upon the south of the Vatna Jökull when the wind is in the N.N.E. And I have found that they increase in pungency of odour the further north I have advanced upon the mountain.

ORDINARY MEETING, MARCH 5TH, 1875.

WILLIAM CARRUTHERS, Esq.; F.R.S., F.L.S., F.G.S., President, in the Chair.

The following Donations were announced :—

" Quarterly Journal of the Geological Society," Vol. xxxi., part 1; from that Society.

" Abstracts of Proceedings of the Geological Society;" from that Society.

" Transactions of the Manchester Geological Society," Vol. xiii., parts 6, 7, 8; from that Society.

" Researches in the Roman Castrum at Richborough," by Geo. Dowkar, F.G.S.; from the Author.

"Geographical Dynamics," by Sir W. Thomson; from N. T. Wetherell, Esq.

"On the Cultivation of Organic Science," by Dr. Grainger; from N. T. Wetherell, Esq.

"A Reminiscence of Dr. Mantell;" from N. T. Wetherell, Esq.

"Miscellaneous Proceedings of the Royal Society;" from N. T. Wetherell, Esq.

The following were elected Members of the Association:—

M. Charles Barrois; Howard Beadall, Esq.; Patrick Donovan, Esq., J.P.; Matthew Greene, Esq., M.R.I.; R. M. Johns, Esq., and Charles Junius Tinson, Esq.

The following Paper was read:—

ON THE RELATIVE AGE OF SOME VALLEYS IN THE NORTH AND SOUTH OF ENGLAND, AND OF THE VARIOUS AND POST-GLACIAL DEPOSITS OCCURRING IN THEM.

By CHARLES E. DE RANCE, Esq., F.G.S., H.M. Geological Survey.

In the early days of Geological Surveying it was the custom to disregard the various deposits of clay, sand, loam, and gravel, which were believed to have been scattered by "diluvial forces" over the surface of what were called the regular formations.

As the application of Geology to Agriculture, Engineering, and Medical Science increased, an exact knowledge of the various Drift, or superficial deposits, became of importance, for in many districts they entirely cover up the older rocks, in some instances to a depth of 400 feet, and exercise a more important influence on the pursuits, health, and condition of the people living on their surface, than do those older formations, which are alone shown, on ordinary geological maps.

A detailed examination of these Drift deposits, in various parts of the British Isles, proved that so far from their having a common diluvial origin, their structure is exceeding complex, due to a number of forces, acting through long periods of time, during which great climatal changes took place. Some of these beds being due to the melting of stone-laden icebergs in a Glacial sea, others to the ground moraine of an ice-sheet wrapping over large portions of Britain, whilst other deposits, though formed after the period of cold had passed away, were the old alluvial sediments brought down by existing rivers, before they had cut down their valleys to their present depth.

Whilst yet other deposits, though later in time than the newest Tertiary period, were yet pre-Glacial, expressing a Continental period, which forms a link between the present and past, during which, through old forms of life constantly becoming extinct, and new species appearing from other areas, there was a constant series of over-lapping, the new emigrant being ever present at the death of the original inhabitant, whose ground it occupied, to whose extinction it contributed in the struggle for life, and whose place in the economy of nature it took up.

The completion of the maps of the Government Geological Survey, with the superficial deposits expressed, of two important districts, viz.:—the Thames Valley around London, and the whole of South Lancashire, enables us for the first time to compare the sequence of the two districts one with the other, with a view to seeing how far they may be correlated, and how far, by light borrowed from the one we may read the history of the other.

GLACIAL DRIFT OF LANCASHIRE.

The high watershed forming the Eastern margin of Lancashire, along the Yorkshire border, is for the most part a Driftless area, but in the Coal Measures basins lying between the various spurs, thrown out westwards from this Pennine watershed, between the Mersey and the Ribble, Glacial Drift occupies the valleys and creeps up the hills to a height of 500 and even 1300 feet.

North of the Ribble, the Fells, forming the watershed, end off more abruptly, and overlook the Drift-covered plain of Lancaster, Garstang, and Preston, a continuation of the Triassic and Coal Measures Drift-covered plains to the south.

Between Warrington, Wigan, and Ormskirk this lowland plain is subject to undulations, sections proving the Drift to wrap round a pre-Glacial system of hills and valleys, the rock often cropping out at the top of the hills, but in the plain northward of Wigan and Ormskirk, Glacial Drift overlies a pre-Glacial rocky floor rising slightly inland, and situated far beneath the present high-water mark under the line of the existing sea-coast. So that rock sections are hardly ever seen, and inland are only met with in the beds of the streams at the bottom of the deepest valleys.

At Preston and Blackpool, the Glacial Drift exhibits what may be called its normal sequence in the north west of England, consisting of:—

Upper Boulder Clay . . .	About 80 feet
Middle Sands and Shingle . .	„ 60 „
Lower Boulder Clay . . .	„ 30 „

The Sands in West Lancashire are exceedingly current-bedded, generally in a S.S.E. direction, the shingle-beds are often of considerable thickness, very local, and contain perfectly rounded pebbles and numerous marine shells, some of the latter exceedingly perfect though excessively fragile. The pebbles are chiefly derived from local deposits, but when Lower Boulder Clay is present in the district, the fragments consist of erratics from the Lake District, often more or less scratched. When the Sands and Shingle are found high up in a Coal Measure, or Millstone Grit district, fragments rolled into pebbles of Coal Measure sandstones, coal, and Millstone Grit are common.

When sections of the bed of the Ribble, its tributaries, or other rivers taking their source further inland are observed, the Glacial deposits are found to occupy old pre-Glacial valleys, producing the phenomenon, termed *Valley within Valley*, the existing valley being excavated in the Drift, and of a much smaller sectional area, and as Mr. Tiddeman in 1867 pointed out, many of the brook valleys of North East Lancashire and West Yorkshire are merely re-excavations and enlarging "fossil water courses, following in the steps of the pre-Glacial pioneers."

In the Furness district of North Lancashire, the same general sequence of Glacial deposits obtains; Upper Boulder Clay rests on sands and gravels at Ulverston, and a Lower Boulder Clay can be seen resting on the rock, but in following any of the streams reaching the sea in this district into the deep valleys of the Lake District from which they flow, the sequence is lost, and the character of the Drift becomes more and more confused as the mountains are approached. Well preserved moraine mounds occur in numerous valleys, far above the level of glaciated rocks lower down in the valleys, and there is clear evidence of an early excessive glaciation, during which era those lakes which lie in the rock-basins probably came into existence, and of later nestling glaciers, which shrunk gradually as the period of glacial cold passed away.

Glaciers large enough to have deepened valleys into rock-basins and score their sides with striæ, must have left large moraines, almost the only evidence of which now exists in their transported fragments lying scattered over the plains of the south imbedded in the Boulder Clay. And it is in the highest degree probable, that all trace of these old moraines of the Lake District were obliterated, first by the deposition of marine deposits on them, during the submergence, and secondly by the denuding away of the material filling up the valleys by the glaciers of the second period, which, judging from their well preserved moraines, must have existed after the re-elevation of the land. The amount of moraine sediment deposited in the valleys of the Lake District was probably comparatively small, through their being filled with land ice during the submergence.

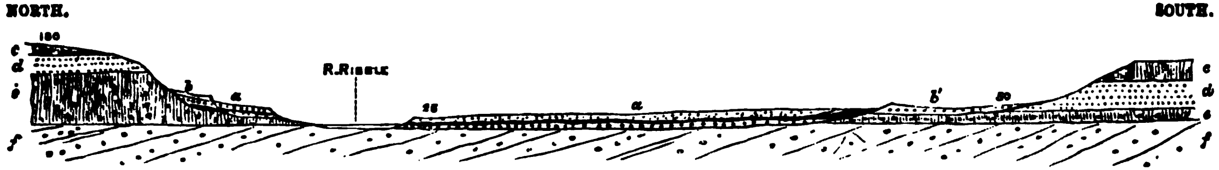
In some sections in South Lancashire, as at Brinscall, the Middle Sands do not rest on a Lower Boulder Clay, which generally resembles the Upper Boulder Clay in colour, consistence, character of included fragments, and in the presence of marine shells, but on a dark tough clay, resembling the "Till" of Scotland, and formed like it by the grinding of an ice-sheet over a local area. Near Llandudno in North Wales I noticed a bed of Till of this description, underlying the ordinary Lower Boulder Clay, Middle Sands, and Upper Boulder Clay; so that I am inclined to correlate the Till with the period of the formation of the rock-basins and the glaciated surfaces of the North of England found beneath the later marine beds known as the Lower Boulder Clay, &c.

POST-GLACIAL VALLEY DEPOSITS.

In some streams denudation is threefold: *vertical*, cutting the channels downwards, always acting from below upwards, or from the outfall towards the source; *longitudinal*, cutting away the banks on both sides when the streams flow straight, and the outer side only when it flows in a curve; and *horizontal*, when the streams or rivers, through excessive curving, in addition to wearing the edge of its channel wears it completely backward, causing the water to be thrown diagonally at the hill or bluff forming the limit of the valley, which thus receives the whole horizontal width of the stream. Gravel is constantly brought down by the rush of the stream during floods, but is only deposited in the river-bed, while the matter held in suspension is deposited on the banks

SECTION 1.

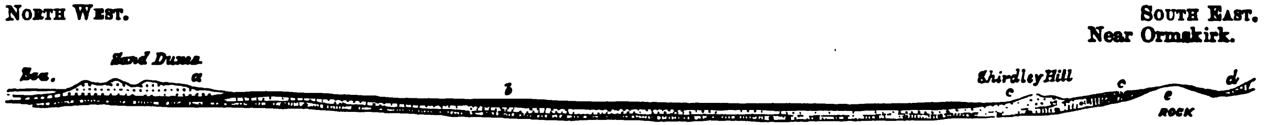
THE VALLEY OF THE RIBBLE.



a. Alluvium of the Ribble, consisting of Loam, Peat, and Gravel.
b. River Terrace, with the same sequence of deposits as *a.*
c. Upper Boulder Clay.
d. Middle Sands and Gravel.
e. Lower Boulder Clay.
f. Pebble Beds, of the New Red Sandstone.

SECTION 2

SECTION FROM SOUTHPORT TO NEAR ORMSKIRK.



a. Sand Dunes. *b.* Peat. *c.* Shirdley Hill Sand, a range of ancient Sand Hills.
d. Boulder Clay, overlaid by *Scrobicularia* Clay in the western area, which partly overlies the Shirdley Hill Sand.
e. Rock—Keuper Marls and New Red Sandstone.

when the velocity of the water is lost or diminished. When the river has cut as low as it can and the land remains stationary, the course is constantly being changed, and the gravels deposited at a previous time re-arranged; remarkable instances of this are shown by Mr Fergusson to take place near the Delta of the Ganges. The river in undermining old banks and terraces, and re-depositing their materials in newer banks and alluvial flats, mixes included fragments of various ages in one deposit.

VALLEY OF THE RIBBLE.—The first section (Section 1) to which I would wish to draw attention is one across the valley of the Ribble, a few miles east of the town of Preston. The river has here cut through the great Drift plain between Chorley and Lancaster down to the rock beneath, and excavated its bed, near Preston, to the lowest possible level, namely to low-water mark, the spring tides flowing two or three miles up the river beyond the town. The river has excavated for itself a gorge, with an average width of a mile and a half, bounded by steep walls or bluffs, here and there worn into cliffs, exhibiting fine sections of the Glacial Drift, of an elevation varying from 80 to 200 feet.

The whole of the excavation of this gorge, 20 miles long and 150 feet deep, must have taken place since the era of the Upper Boulder Clay, or in post-Glacial times, and since the country had acquired its present level; for if the country had stood lower, the sea would have shaved the country across, instead of excavating a comparatively narrow valley; and if the country had stood higher, the river would have excavated its bed deeper, or below low-water mark, which is not the case, as, whenever the rock is visible, it is seen extending under the Drift as a flat surface, in every direction.

The Ribble wanders in a series of S-like curves through an alluvial plain; and wherever the bend of the S cuts the boundary-walls of the plain, there the process of river-cliff making ensues: the cliff is worn back and back, until the river, by cutting across a bend, finds a new channel; then the talus formed at the base of the cliff, being no longer removed by the river, accumulates, until a gradual slope, covered with grass, is formed, and the cliff becomes a bluff. As the bends of the river are nearly a mile apart, and they alone exercise the primary horizontal denuding power, it will be seen that, for the formation of the bluffs, once cliffs, the bends of the river must have been successively upon every point of the bluffs forming the bounds of the plain. And as the vertices of these bends move with extreme slowness, it follows that, when the river twice denudes the same point, it must flow at a *lower* level the second time than it did the first. This will account for the fact that terraces of Lower Boulder Clay have been left at the base of the bluffs at higher levels than the alluvial plain, the top of the terrace marking the level of the river when it last denuded that point.

The river is now depositing silt, or alluvium, during every flood produced by a freshet from the land or a high tide from the sea, except at the points where denudation of the old banks is at work. Similarly we find here and there superimposed terraces of alluvial gravel, at heights of from 20 to 100 feet above the present level, formed in the concave curves of the S's when the stream stood higher than at present, and cut the terraces in the Lower Boulder Clay before referred to.

The wasting action of the river has in many cases completely worn away all the alluvium, and turned the bluff bounding the valley into a steep cliff, with the river flowing at its base, but at the point where Section 1 is taken, the river has not completed its work, and fragments of old river terraces above the level of the present alluvial plain are still preserved.

A detailed section of these terraces, though of course subject to local variation, closely corresponds in sequence of the nature of the beds composing it with that exhibited in by far the larger number of the sections of the present alluvial plain, namely—

1. Sand, Loam, Fine Gravel.
2. Peat, Trunks of Trees and Clay.
3. Coarse Gravels.

Probably representing—

1. *Deposition* of matter denuded from alluvial plains above.
2. *Obstruction* of drainage.
3. Denudation of valleys above.

West Lancashire Sea-Coast.—Following the Ribble to its delta the coast line is found to be fringed with broad tracts of sand hills or dunes, rising to a height of 60 to 80 feet, and occupying a tract of country from a mile and a half to four miles in width. The sand gradually thins out on the landward or eastward margin, and is found to rest upon peat, which form extensive masses between Liverpool and the Ribble near Preston, many of which are below high-water mark, the sea being kept out by the sand dunes, and the drainage being artificially taken off by steam and wind power.

Beneath the sand dunes on the sea-coast also the peat crops out, and at its base occur the roots of a forest, imbedded in the grey clay beneath, while trunks of trees lie scattered in many directions, but generally with their heads lying to the N.E., as if they had been blown over by a gale from the S.W. The bases of the trunks left standing in the places where they grew, all appear to have been broken off at a uniform level; and it is most probable that through the drainage being obstructed, water surrounded the trees, which gradually became rotten at the point of contact of the air and the water, and thus the way was prepared for the effects of storms and hurricanes.

Inland the same phenomena are observable, trees are found *in situ* beneath the peat, and in draining operations cart loads of trunks and snags of trees are found, some of which are in a sufficiently good state of preservation to be used for window frames and doors, especially those of oak. Alder, ash, and Scotch fir, are also common, and the various trees generally occur together, but an exception is to be found at a section north of the Ribble near Rossal School, where there is a distinct horizon of oak, over that of Scotch fir, as is the case in Denmark. A little north of this section, about two miles from Fleetwood, a large number of Roman coins were discovered in the *Scrobicularia*-clay, which overlies the peat at a depth of eight feet from the surface, and below high-water mark, so that the levels of land and sea have remained very constant since the Roman era. This is also supported by the fact of the occurrence of the remains of a Roman bath, at Dow Brook near Kirkham, close to the Roman road running between Ribchester, Preston and the sea, which "bath" and road are only about 10 feet above the present high-water mark at spring tides.

Under the peat, on the seaward side, and extending inland for some miles, is a deposit of estuarine grey clays, containing at times freshwater shells, and at other places *Scrobicularia piperata* and other marine shells; underlying this clay, and further inland under the peat, is a deposit of marine sand, which, on the landward edge of the plain, rises into a range of ancient sand dunes. This sand I have called the Shirdley Hill Sand, from the highest of these old sand dunes. North of the Ribble, the place of this sand is taken by a bed of shingle which is well seen near Presall Hill east of Fleetwood, where it lies on the Upper Boulder Clay. When the sections in the great peat moss lying south of the Ribble, are followed into the region of the alluvium of that river, the peat is found to underlie the ordinary alluvial loam, and rests on a coarse river gravel, which occupies the horizon in the valleys of the Shirdley Hill Sand and Presall shingle-beds in the plains.

Beneath the sand dunes at Dove Marks, near Hoylake on the coast of Cheshire, the following succession of beds occurs :—

	ft.
1. *Bithynia tentaculata* Sand	2 to 4
2. Peat, sometimes with a cultivated surface	1
3. *Tellina balthica* Sand, with seams of Bluish Clay. This is apparently the seam in which Mr. Ecroyd Smith has recorded the presence of Saxon and Roman coins	2
4. Peat. The representative of the thick peat of Lancashire and Cheshire	3
5. Bluish-grey Clay, the upper portion of freshwater origin	3
„ „ the lower of marine, and containing *Scrobicularia*	1
6. Peat, with a few stumps of trees with their roots in	1½
7. Boulder Clay. From half-tide to the lowest water-mark.	

In the lowest peat (6) no historical or natural remains have, I believe, ever been found; but some of the flint weapons in the Liverpool Museum are believed to have come out of this seam, others from the base of the peat above. In addition to the flint weapons, Mr. Ecroyd Smith believes it to contain bones of *Bos primigenius* and *Megaceros Hibernicus*, and of Cetacea; but these bones, I think, possibly are those that were found in the blue silt resting on a peat bed with a forest on its surface, in excavating Wallasey Pool for docks in 1858, and which have been described by Mr. T. J. Moore in the "Lancashire Historic Society's Transactions." In this case they are more probably of the age of the *Tellina balthica* sand, as the peat in Wallasey Pool no doubt belongs to the main or thick peat of the district, which, near the Birket, attains a thickness of nearly 20 feet. In this peat bones of horses, oxen, and deer have been found, as well as great numbers of Roman and Saxon coins, and in one portion arrow-heads of stone, shell, and flint. The latter substance must have been brought to the spot, either from southern counties or from eastern Yorkshire.

Great numbers of coins of all ages are constantly being picked up on the North-Cheshire beach, most of which are no doubt washed out of the main peat and the overlying *Bithynia* and *Tellina* sands. Amongst those preserved in the Liverpool Museum are some of Nero, Antoninus Pius (A.D. 138-160), Marcus Aurelius, others struck at Carthage, others struck by Canute and by various English kings from William I. to William III. Various antiquities have been described by Dr. Hume from this coast in his "Ancient Meols;" but the exact position from which they were derived is in almost every case extremely doubtful. But after carefully examining all the objects from the coast of Wirral in the Liverpool Museum, as well as the coast-section, the following correlation of historical periods with the geological formations appears to be warranted:—

Present time to Norman Conquest	Sand Dunes.
Danes and Saxons	*Bithynia tentaculata* Sand.
Saxons	Peat and Made Earth.
Saxons and Romans	*Tellina balthica* Sand.
Romans and Celts	Main Peat.
Celts	„ lower portion.
Neolithic-weapons race	Lower Blue Silt.
No trace of man	Lowest Peat.

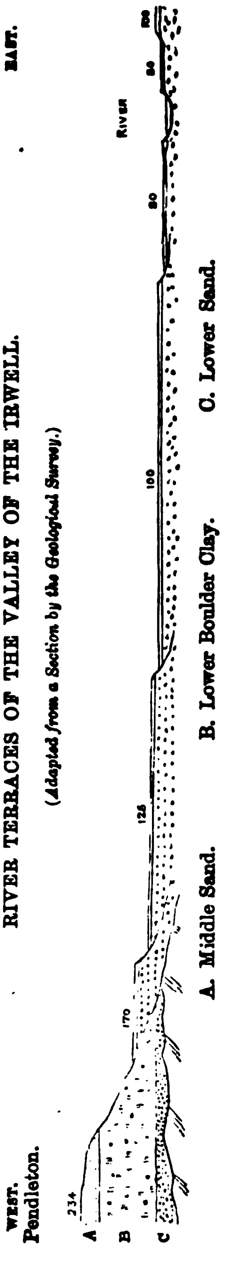
These extensive peat and forest-beds from occupying a similar position around all the low coasts and the entrance to almost all the larger rivers of England and Wales, must belong to the same episode in post-Glacial history, during which continental conditions prevailed.

VALLEYS OF THE IRWELL AND UPPER MERSEY.—So far back as 1847, Mr. Binney, F.R.S., described the occurrence of terraces of coarse gravel with beds of sand, occasionally stratified, on the sides of the three great valleys near Manchester, and he gave a section across the valley of the Irwell, from Pendleton to Kersall Moor, showing *that* valley to have been mainly excavated at that point in the Glacial Drift. The valley of the Irk, between Crumpsall and Harpurhey, is also cut through the Drift, with terraces of Drift at the bottom, on the New Red Sandstone and Coal Measures; but in the narrower part of the valley further south, the alluvial terraces disappear, but come on again where the stream falls into the Irwell. The Medlock at Bradford and

SECTION 8.

RIVER TERRACES OF THE VALLEY OF THE IRWELL.

(*Adapted from a Section by the Geological Survey.*)



A. Middle Sand. B. Lower Boulder Clay. C. Lower Sand.

Berwick is also cut out of Glacial Drift, down to the Coal Measures, and on the south side of the stream at Ardwick commences that great sheet of alluvial terraces which extend through Hulme, Manchester, and Salford, along the course of the Irwell. Mr. Binney, like all other geologists of that period, in this paper refers the formation of these valleys in the Glacial Drift to the action of the sea, believing the present streams to be inadequate to the work.

In 1862 Mr. Binney exhibited a map of the Drift Deposits around Manchester, showing the Valley Gravels, and described the highest terrace in the Irwell valley as occurring below Barr Hill, 86 feet above the present river; another terrace occurring at 40 feet near to Pendleton Colliery, where there is a good section of it, which with many others in the district Mr. Binney was good enough to show me in January last. I was particularly struck with the section at Clifton Junction, where about 40 feet of bedded gravel abuts against an old cliff of Glacial Sands and Gravel, which it so closely resembles that it was not until Mr. Binney had shown me a great number of sections throwing light upon it that I was convinced of the correctness of his conclusion. But the resemblance can readily be understood when it is remembered that these Valley Gravels are merely re-assorted Boulder Beds and Gravels, made up of erratic fragments derived from the Lake District; and when the frequent occurrence of shells of recent species in the Lancashire Middle Gravels is considered, it is not at all remarkable that a few isolated marine shells should be found in these fluviatile Valley Gravels, as the *Cardium edule*, discovered by Mr. Barr at Stockport.

The river Irwell below Kersall Moor, near the Manchester racecourse, has changed its course, as proved by old plans, during the last two hundred or three hundred years, several acres of Salford now being on the Kersall side, and about the same area of Kersall on the Salford side of the river; for, as pointed out by Mr. Binney, there can be no doubt that the river was once the boundary of the two townships. Under the lowest terrace, or rather at the bottom of the alluvial flat below the terraces, peaty beds and trunks of large oak trees occur in several sections, resting on about six feet of river gravel.

Professor Hull, F.R.S., in 1863 described the great terrace about 40 feet above the alluvium of the Mersey, which rests on Boulder Clay, and is seen in the pits of Cheadle, Didsbury, Bromyhurst, and Barton Grange, where it underlies the thick peat of Barton Moss. From Didsbury the Gravel may be traced through Withington, Hulme, Old Trafford, Patricroft, and through the great plain lying between the banks of the Irwell and Mersey, and extending into Cheshire as far as Timperley and Altrincham. Neither in the terrace, or in that of Lower Broughton, six feet above the present alluvial flat, which is still liable to floods, could Professor Hull find any organic remains.

At Grundy Hill, east of Didsbury, 50 feet above the Mersey, Professor Hull discovered the following section:—

	Feet.
1. Fine laminated White Sand	2
2. Layer of peaty matter, with birch or hazel .	¼
3. Dark laminated Clay	6
4. BOULDER CLAY.	

The laminated clay No. 3 was believed to be "warp," formed when the river had a broader spread across the valley, and deposited the high terraces.

Between Worsley on the north and Altrincham on the south, the breadth of the terrace is seven miles, and the present river valley 50 to 60 feet beneath the highest part of it.

From the investigation of the South Lancashire Valley Gravels it would appear that (1) the Upper Mersey and its tributaries were mainly pre-Glacial; that (2) during the Glacial Epoch they became filled up with Boulder Clay and interbedded sands; that (3) since the period of extreme cold and the re-elevation of the land, they have been re-excavated by the existing rivers, which have left marks of their former higher levels in the terraces, lying on successive heights on the sides of the valleys, the higher and older terrace, in some cases, being as much as 100 feet above the present level of the streams; and that (4) immediately before the deposition of the alluvium of the present alluvial plain, but after most of the valleys had been cut down as low as they are at present, a period of obstruction of drainage took place, and peaty beds were formed in the bottom of the valleys at the same time that the great "mosses" of West Lancashire came into existence.

Comparing the sequence of deposits of the whole of the valleys and plains of West Lancashire, the major part of all the valleys appear to have been excavated between the era of elevation of the surface of the Boulder Clay into land and the time when the maximum of that elevation was reached, when the Isle of Man formed a link in a chain of continuous plains, stretching between the north-west of England and Ireland, which plains afterwards became peat-covered, and by a succession of small subsidences perhaps not yet completed, were let down beneath the Irish Sea.

Investigation of the valley deposits of Central England point to the large amount of denudation which has gone on since the close of the Glacial Epoch, and prove the post-Glacial age of the terraces hanging on the sides of those valleys, as those of the Trent at Burton, described by Mr. Molyneux, F.G.S., and in many valleys further south.

VALLEY OF THE AVON.—Mr. T. G. B. Lloyd, C.E., F.G.S.,* describing the valley of the Avon, mentions terraces of fresh-water deposits, consisting of quartzose flinty gravel and sand, containing land and freshwater shells and mammalian remains, obtaining their maximum superficial development between Evesham and Tewkesbury, having a width of about a mile and a-half, and rising about three feet in height above the ordinary alluvial plain. In the Gravel Pit near Little Comberton occurred the fine tusk of *Hippopotamus major*, now in the Worcester Museum. The lower part of the section was found by the Rev.

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* Quart. Journ. Geol. Soc., Vol. xxvi., p. 202.

W. Parker to consist of freshwater shelly clays, and in the gravels above were erratic fragments derived from the Boulder Beds; so that it is clear that the whole series are of freshwater origin, and of post-Glacial date, though in some cases they are as high as 40 feet above the river. Mr. Lloyd describes these terrace beds as being absent in the valley of the Severn between Shrewsbury and Tewkesbury, the marine shells and bones of *Rhinoceros tichorhinus* and *Elephas primigenius* that have been recorded having been derived from the Boulder Clay and other Glacial deposits.

Having described the probable age of the valley deposits of a large tract on the west side of England, where their relation to the Glacial Epoch is observed, and the occurrences of neolithic implements, relegated to the beginning of the formation of the lowest alluvial plain of all, it may be well to notice those sections in the east of England where palæolithic implements occur in valley deposits, the relation of which to the underlying Boulder Clay and other glacio-marine deposits is clear.

At Hoxne, near Diss in Norfolk, Professor Prestwich has described the occurrence of high level gravels with flint implements, resting on sand and gravel with implements, the bones of Mammalia, and fresh-water shells, lying on peat and clay, the whole series occupying a hollow or filled lake or water-course in the Boulder Clay.

At Bedford, in the ancient high-level gravel, lying in a valley which has been cut through a thick bed of Boulder Clay and into the Oolitic strata entirely since the Glacial Epoch, occurred numerous flint implements of the French or St. Acheul type, described by Messrs. Prestwich, Wyatt, and Evans. Here since the Boulder Clay extended across the valley from side to side, the rain has cut down this valley two miles in width, and to a great depth, so that the valley is as clearly post-Glacial as those in the north, where no palæolithic implements have, as yet, been found.

In the Lake District of Cumberland and Westmoreland traces of high-level river terraces are generally absent, or, if present modified by late *glacier action*, and I think from the large size of many of the blocks in terrace gravels of Lancashire, they are probably ice-borne, and that the climate of the north-west of England, during the first re-excavating of the valleys, was too cold to be inhabited by man, which accounts for the absence of implements of old type in the terrace gravels there. Which fact, if true, forms an important link in the chain of phenomena by which I have endeavoured to correlate the sequence of conditions obtaining in the north-west of England, with those which occurred in the south.

VALLEY OF THE THAMES.—Professor Ramsay has well shown how the great elevation of new mountains on the flanks of the *older* Alps, at the close of the Miocene period, gave the Secondary strata, lying until then in horizontal continuity over what is now England and France, their existing low tilt or dip to the north-west. Which tilt gave the initial north-westerly direction to the existing rivers of northern France, the Loire, the Seine, the Marne, and the Oise; and by causing the Chalk of England to form a gentle slope towards the hilly country of Wales and Herefordshire, forced the Severn to run in a southerly direction, and established the first beginning of the great Chalk escarpment that has since been cut so far back by subærial causes. But, before it was cut back any great distance, further disturbances of the strata took place to the east of it, giving the Chalk and overlying Eocene strata a decided tilt to the eastward, which caused the drainage of the Chalk area to flow away eastward. The Thames then came into existence, and commenced to cut for itself a valley through the Chalk, the escarpment of which continued to gradually recede eastward, and from overhanging the valley of the Severn (which, as the Oolitic escarpment also retreated eastward) gradually widened, gaining in extent at the expense of the Thames, which gradually contracted its drainage area.

The gradual eastward retreat of the Chalk escarpment at length bared the edges of the Oolitic strata, which had already obtained their south-easterly dip before the deposition of the Cretaceous strata, which, being of unequal hardness, formed another line of escarpments which also commenced retreating eastwards, but at a far slower rate than the more readily soluble Chalk, the distance between the Oolitic escarpment of the Cotteswolds, and the Chalk escarpment to the east of them, having gradually increased from that day to this, and the process being still in existence, so that the time must come when the Oolitic escarpment forming the present Cotteswolds will have retreated so far eastward that the larger portion of what is now the valley of the Thames, will, through the travelling of the water-shed towards the sea, become a part of the valley of the Severn.

The Chalk, resting on the Oolites with a south-easterly dip, was at length cut down by the retreat of the escarpment to a point relatively lower than the newly-formed Oolitic escarpments to the west of it, which allowed all the water falling on the surface of the Oolites between their escarpment to the west, and the Chalk escarpment to the east, to flow down the dip of the Oolites, and into the Thames valley excavated in the Chalk, which was gradually deepened as the escarpment increased in height, so that in time it was entirely breached by the river which flowed through it.

The map of the Geological Survey, with London in the centre, includes the principal portion of the Valley of the Thames, and I have taken it, and the Superficial Deposit edition of Sheet 7, and the "Ordnance Contour Map" published by the Royal Rivers Commission, as the basis of the following observations.

The chief source of the Thames is about 600 feet above the sea; from it to the 300 feet contour the stream descends a horizontal distance of nine miles, and 11 miles more to the 200 feet contour near Lechlade, from which place to the point where the river flows through the Chalk escarpment at Wallingford, near Stoke, is a distance of 42 miles, while to the 100 feet contour is an additional 30 miles, which is reached near Great Marlow, from which the Thames descends 75 feet, at London Bridge 48 miles further on.

The top of the Chalk escarpment, near the Thames, is about 100 feet lower than its source, so that supposing the valley of the Thames not to have been excavated, and the river to flow along the plain, at the top, the stream would have a fall of 100 feet in 62 miles—a fall very similar to that now obtaining between the 200 and 100 feet contours, which are 72 miles apart.

Capping many of the flat-topped hills lying between the valley of the Lea and the escarpment of the London Clay and Plastic Clay, overlooking the Chalk, about Rickmansworth, Watford, and St. Albans, are the Pebble Gravels of probably pre-Glacial age. It will be noticed that with two slight exceptions of patches of gravel on the Plastic Clay, that these Pebble Gravels do not occur in the country lying immediately north of the escarpment. The Chalk is overlaid by an extensive sheet of Middle Glacial Sands and Gravels, through which narrow valleys have been cut exposing the Chalk beneath. Here and there small outliers of Plastic Clay occur, remnants marking the former position of the escarpment further out in the Chalk plain, but what is very important is the fact that on the top of one of these outliers is a patch of the old Pebble Gravel; this small tract is about a mile south of Amersham, and quite seven miles from the Plastic Clay escarpment.

From these facts it is difficult to resist the conclusion that the Pebble Gravels were deposited on an old plain of Lower Tertiary beds, the northward portion of which has been destroyed by the wearing back of the escarpment to its present position.

Eastward of the valley of the Lea, the Pebble Gravels cap the heights of Epping Forest, and underlie the Boulder Clay east of Epping Station. South of Brentford, as at Hampstead Hill, these gravels rest on the Lower Bagshot Beds.

In the valley of the Thames and Lea, that is to say on the slopes lying above the alluvial plains, the gravels do not occur, but on the south side of the valley, two outliers remain at Shooters Hill and Telegraph Hill, Swancombe Park, to testify to the height and lines of the old pre-Glacial valley of the Thames. Whether the old gravels capping the low hills about Oatlands Park, and Virginia Water, belong to this age is somewhat doubtful, but they appear to have been deposited during the same set of conditions.

The Middle Sands and Gravels spoken of as occupying the Chalk area, north of the Watford Escarpment, lie at the foot of it, move transgressively over it, and are found far away on the London Clay to the east, and are consequently of newer age than that of the escarpment. On the other hand not only do none of the Middle Sands, or the Boulder Clay occur on the south side of the Thames, but no traces occur on the valley slopes on the north side. The most southern tract of the large mass of Boulder Clay between Brentwood and Epping is that at Havering-atte-Bower, which is about a mile and a half north of the termination of the Thames Gravel of Romford, the level of the latter gravel being about 60ft., and of the Boulder Clay more than 300ft. A most interesting relation of the Glacial Deposits is well shown on the Survey map, where the Middle Sands, covering a large area, at Black Park and Stoke Common, west of Uxbridge, extend to within a quarter of a mile of the Thames Gravel of Stoke Pogis and Farnham Royal, and within five miles of the Thames at Windsor, and separated from the gravels by the scarp of London Clay, which is shown in the Horizontal Section of the Geological Survey, Sheet 74.

From the abrupt manner in which the southern extension of the

Glacial deposits is cut off, there can be little doubt that the older slope, on which they rest, has been denuded away since the time of their deposition, or in other words that the valley of the Lower Thames, with its various sheets of terrace and alluvial gravels is newer than these Glacial deposits. From the fact of the latter being sparingly represented immediately north of the Thames Valley, their thinning out southwards, and their entire absence south of the valley, one must conclude their southern limit on the pre-Glacial plain would nearly correspond to the course of the existing river Thames.

It has already been shown that the river to flow over the Chalk escarpment from the lowest of its several sources, would only have a very slightly greater angle of fall than it has between the 200 and 100 feet contours, lying respectively on the landward and seaward side of the Chalk escarpment; but it is evident from the levels of the top of the Thames Gravels between Windsor and Stoke Pogis, where the valley is only four miles wide, that a considerable portion of the gorge through the escarpment has been excavated since these gravels first commenced to be deposited, and since the denudation of the southern edges of the Middle Drift. When the former channel of the Thames, where it flowed through the Chalk escarpment, was only as high above its present level, as the Stoke Pogis, and Acton gravels are above its present level, the river must have had 100 feet fall more than at present between the Chalk escarpment and the sea.

The Thames Gravel Professor Prestwich described in 1857* as consisting of angular flints, and other pebbles exhibiting a want of roundness, indicating an absence of marine action, associated pebbles of quartz, and various semi-crystalline rocks, rolled into pebbles during the New Red Sandstone period, and derived from the Drift, as pointed out by Dr. Buckland,† who traced the fragments in the Warwickshire Drifts, to their parent source in the Bunter conglomerates of Cannock Chase. The presence of these pebbles in the Dartford gravels was noted as long ago as 1853 by Mr. Trimmer,‡ who pointed out the terrace arrangement of the ground at a height of 150 feet above the tidal level.

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* ' Ground beneath us." London. 1857. Quart. Journ. Geol. Soc., Vol. vi., p. 201. Vol. xi. p. 107. Vol. xii., p. 131.

† Quart. Journ. Geol. Soc., Vol. i, p. 310.

‡ "On the Origin of the Soils which cover the Chalk of Kent." Part. 3. Quart. Journ Geol. Soc. Vol. ix., 1853.

In 1860, Professor Prestwich pointed out that these terrace gravels "are the results of river action at a period before the excavation (? deepening) of the present river valleys," and attributed the transport of large blocks to river-ice, and to the fact that the rivers were larger and more rapid than at present, as proved by the coarseness of the gravels and the absence of sand ; flint implements appear to be most common where re-action is stronger.

In the low-level gravels, implements are absent, and Professor Prestwich attributes this partly to those found in the high-level gravels being used as ice chisels, while the low-level beds were deposited when warmer conditions prevailed in the period immediately following the high-level or terrace gravels. That these various gravels were deposited by the existing river, there is ample evidence to show, and that the higher terraces were deposited when the river Thames had not cut down its valley as low as at present, and of more ancient date than the sheet of gravel occupying the lowest plain. But exactly what the conditions were, when the deposition of high-level gravels ceased, appears to be doubtful; in the neighbourhood of London there is a decided step, or belt of London Clay between the two sets of gravels, first indicated by Mr R. W. Mylne, F.R.S.,* and since proved in the neighbourhood of the New Law Courts, by Messrs. Hudlestone and Price, in a paper in the "Proceedings" of this Association. This bare strip of London Clay, expresses a change in deposition during which the climate ameliorated. This break is not apparent higher up the valley, as in the Maidenhead district, where the low-level and terrace gravels are described by Mr. Whitaker as similar in character, containing occasionally, as pointed out by Professor Prestwich, pebbles from the New Red conglomerates, and more rarely fragments from the Oolites. East of Maidenhead, the gravels have a width of four miles, while to the west, in the Chalk country, they are restricted to a breadth of from three-quarters of a mile to two miles. Between Marlow and Henley, the gravel is mainly made up from the *débris* of the Chalk itself; at Hurley, at a depth of eighteen feet, occurred a large number of mammalian remains, including the hippopotamus and the cave tiger. Similar mammalian deposits occur at Brentford, on the seaward side of London, associated, as long since pointed out by Professor Morris, with fluviatile shells, which he believes lived near the spot. The mammalian fauna of the gravels near Kew Bridge, described by

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* "Geological Map of *London*," Stanford, London, 1851.

Trimmer and Morris, belong to the mid-terrace. In the higher terraces of the neighbourhood of Acton and the Thames, lying beneath the 100 feet contour, Colonel Fox has obtained a large number of flint implements, associated with a tree believed to be *Pinus sylvestris* by Mr. Carruthers, and *Elephas primigenius* identified by Professor Busk, the only tooth of that species found in the high-terrace, the fauna obtained from the mid-terrace by Professor Morris occurring beneath the strip of London Clay before alluded to. The flint implements occurred in the mid-terrace of Brentford and Turnham Green, Hammersmith, described by Colonel Fox, or at the 40 feet terrace of the New Law Courts, described by Mr. Hudleston; and in fact no flint implement of the Drift type has been recorded from any gravels, below the fifty feet contour, except those that have been found in the bed of the Thames itself.

The Thames Gravel rests unconformably on the Ilford Brick-earth, as is well seen in the Uphall brickfield, where the brick-earth thins out eastward, and is succeeded conformably by bright-yellow freshwater sands, which contained the tusk of *Elephas primigenius*, the Thames Gravel overlying both the deposits. Northwards the gravel increases in thickness to fifteen feet at Ilford Station, half-a-mile east of which the brick-earth—Lower Brick-earth of Mr. S. V. Wood, junr.—again crops to the surface at the London Road field. At Erith it has a thickness of nearly 30 feet.

Mr. Gwyn Jefferys has pointed out the northern character of the shells *Helix ruderata*, and *H. fructicum*, occurring at Ilford, which deposits may correspond to terrace gravels higher up the Thames, containing the remains of the musk ox, first discovered by Sir John Lubbock, and identified by Professor Owen, in gravel which Mr. Whitaker considers to be a terrace gravel above the gravel of the river plain.

The shell-bearing sands occurring at several points between London and the sea, are of far newer date, being apparent local deposits of a period immediately succeeding the gravels of the lowest plain, and preceding the growth of peat.

The deposit of bright yellow, red, and grey sands, with occasional seams of gravel found under Pall Mall and Spring Gardens, probably belong to the same period as the *Cyrena fluminalis* beds of Grays, for they contain a small variety of the latter shell, and a plentiful mammalian fauna. The dwarfed form of the *Cyrena* may possibly be due to the incoming of brackish water, which idea is, to some extent, borne out by the presence of rolled Thanet Sand fossils, in the ferruginous gravels associated with the sands, suggesting a current from the east, but the bed immediately below is full of ordinary freshwater shells, as *Succinea* and *Lymnea.* The base of these sands at Cockspur Street, rests on the London Clay, at a level of probably less than 10 feet below the Ordnance Datum-line.

In Lancashire there is ample evidence that a subsidence took place, after the main valleys had been cut as deep as they are at present, during which post-Glacial marine beds were thrown down, which era was immediately succceeded by a slight elevation, accompanied by obstruction of drainage. In the valley of the Thames, a similar sequence would appear to have occurred. The Pall Mall and Grays beds, corresponding to the Shirdley Hill Sands and Presall Shingle.

Professor Morris describes the Upper series of beds at Grays, consisting of false-bedded unfossiliferous sands and brown clays, as formerly being seen resting, in clear sections, on the Lower or fossiliferous zone, comprising the gravel and overlying brick-earth, in which the remains of *Cyrena, Paludina,* &c., occur, and expresses his opinion that "the deposit at Grays may be mainly due to the action of a river flowing through a valley which it has partially excavated, in the Lower Tertiary and Upper Chalk beds, and most probably posterior to the Boulder Clay period." Previously to 1857, the late Sir Charles Lyell, whose loss we can hardly realize, and so deeply deplore, believed these beds to be pre-Glacial, and older than those of Brentford, but he in that year stated his uncertainty as to their age.

Mr. S. V. Wood, jun., in 1866, described the Grays deposits as consisting of 15 feet of blue clay, overlain by 20 feet of false-bedded sand, and believes it to be later than his Upper Brick-earth overlying the Thames Gravel, which was faulted by a dislocation, followed by denudation which destroyed all the southern slope of the Thames Valley east of London, with the exception of a remnant forming Shooters Hill. Mr. Wood pointed out that the greater part of the Grays brick-earth partly overlies the gravel of the lower terrace, which is continuous with that of the valleys of the Darent and the Cray, and which is beneath the higher terrace of the brickfield at Crayford.

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* "Geological Magazine," Vol. iv., p. 64.

The gravel of the lowest plain at London, and seawards, is here and there overlaid by alluvium, near the base of which, on the seaward side, is a deposit of peat, which occasionally crops to the surface, as in the Surrey Commercial Docks, which I had lately the opportunity of visiting, where the peat, with trees, rests on the low-level gravel. In the Crossness Outfall boring, 6¼ feet of peat occurred beneath 9 of alluvium. At Deptford the peat was 10 feet in thickness, and in a well at Erith, no less than 20. At Greenwich Marsh 8½ feet of peat occurred in the centre of 20¾ feet of alluvial clays, resting on sand and gravel.

From this it is evident, that the peat underlying the recent Thames alluvium, is much newer than the most recent of the Thames Gravels which underlie it, in a manner similar to that in which the marine Presall Shingle and old river gravels underlie the peat of Lancashire. Colonel Lane Fox points out that the pre-Roman station at Dorchester Dykes at the junction of the Isis with the Thames, proves that the latter river ran its present course, and under nearly the same conditions during the Bronze-period as at present. At the mouth of the Brent at Kew, and at Barnes on the opposite bank, piles of ancient river habitations occur, associated with a number of flint celts, and dolichocephalic skulls of a form believed to have belonged to the earliest inhabitants of these islands, and Colonel Lane Fox comments on the enormous periods of time, since the river excavated its valley—four miles and a half in width—from the 100 feet contour down to its present level, which has practically been unchanged for the last two thousand years..

From an examination of the sections that have been exposed during the last seven years, in making the double line of the London and North Western Railway, between Hertfordshire and Lancashire, I have been led to believe that the sands and overlying Boulder Clays are of the same age in the one county as in the other; but, whether this be so or not, it is certain that these deposits represent *the close of the Glacial* submergence, and that this submergence of the land lessened in extent southwards, so that the whole of the country, south of the Thames, was a long island, as suggested by Mr. Godwin Austin. The Glacial deposits probably extended further south than we now find them, having been removed by that fluviatile denudation which has excavated the lower valley of the Thames since the era of the Boulder Clay. Professor Prestwich has shown that there is good reason to believe that the elevation of the dome of the Weald commenced during the Thanet Sand period, so that the escarpment of the North and South Downs may well have begun to be formed at the commencement of the Tertiary epoch.

Looking at all the observed facts, it appears (1) that the whole of the lower portion of the Thames Valley was excavated since the deposition of the Upper Drift or Boulder Clay; that (2) as the valley was gradually cut down, gravels were deposited, and in still later times gravels and brick-earths. One of the earliest brick-earths that has been preserved from denudation, being the Lower Brick-earth (x 4' of Mr. Searles Wood, Jun.) of Ilford. The gravel overlying, Mr. Wood believes to have been formed by the sea, but from its character, its gradual descending slope and other reasons, I think it is more probably fluviatile, formed when the Thames was a tributary to the Rhine, and the united rivers flowed over the plains of the German Ocean. After which an era of obstruction of drainage occurred, trees grew at the bottom of the valley, and were followed by a growth of peat. Before comparing these sequences with that described in the North of England, it may be well to see what light is thrown on the relation of the two by an examination of the valley deposits of the South of England.

VALLEY OF THE MEDWAY.—Messrs. Topley and Forster, in their paper "On the Superficial Deposits of the Valley of the Medway," describe river gravels as occurring at all heights in the valley of that river, from the present alluvial plain to 300 feet above it, and it is impossible to draw a line between the higher and the lower gravels, and the former, like the latter, consist of pebbles derived from the Wealden Area. Between Allington and Aylesford there is a terrace 20 to 30 feet above the present stream; further down the Medway Valley, near Aylesford, there is a 40 feet terrace, in which occurs the well-known Mammalia-bearing gravel-pit near the church. At the top of a hill near Maidstone Gaol occurs a terrace at 200 feet, and half-a mile east of East Malling Heath gravel occurs at 300 feet above the Medway. Mr. Topley comments on the fall of these terraces down the valley being more rapid than that of the present stream, and remarks that Professor Prestwich had observed the same fact in the valley of the Waveney (Phil. Trans., 1864, p. 252), and Mr. Bristow in the terraces of the Thames Valley. Messrs. Topley and Forster point out that as the gravels are found at all levels up to 300 feet, the river has deepened its bed gradually, and that no agents but rain and rivers have been at work in the Medway basin since the river ran at the 300 feet level, and show how large an area has been denuded in that basin since that period. And they state their belief that the Wealden Area was never under water during the Glacial Epoch.

South-east Coast.—At the top of the West Cliff at Folkestone, at an elevation of 114 feet above the sea, occurs the deposit known as the Battery or Elephant-bed, the eastern extension of which is cut off by the valley terminating at the Harbour, at the bottom of which alluvial beds rest on a peaty seam. To the west the Battery deposit thins out near the church against a much more recent brick-earth, which caps the Lower Greensand. In 1866 I took the following section near the Battery, partly from information received from Captain Sweeney, R.A.:—

	Ft.	in.
1. Vegetable Mould	3	3
2. Kentish Rag flagstones of old Monastery	0	3
3. Clay with oysters, bones of ox (Mediæval remains)	2	6
4. Small Shingle	6	4
5. White Loam, with *Helix concinna*, *Sus oblonga*, *Terebratula*, &c., from the Chalk; and *Ammonites interruptus* and fossils from base of Gault . . .	6	4
6. Large angular flints, with bones of Mammalia, and fragments of Gault Junction-bed	1	6
Folkestone Bed, to sea level . .	95	0

At the back of the ground occupied by the Battery is the Bayle Pond, supplied by a spring in the calcareous bed No. 5, of which there is a monkish legend, that the Lady Abbess by incessant prayer brought the water up the hill. From the Bayle towards the Town Hall the ground slopes away, and the Battery deposit thins out, and is overlaid by the later brick-earth, but I discovered another fragment of the deposit in an excavation for some cottages behind the Viaduct, the section being as follows :—

	Ft.	in.
1. Clay with few angular flints . . .	4	0
2. Band of Dark Clay (Brick-earth like No. 1)	1	0
3. Clay, partially sandy and partly calcareous (equals Bed 5 of Battery bed) .	6	0
4. Flinty gravels, with Chalk fossils, nodules of oxide of iron from the Grey Chalk (equals Bed 6 of Battery) . . .	2	9
5. Folkestone Beds (visible) . . .	4	0

There can be little doubt that the Battery and Viaduct sections are the sole remaining fragments of an old fluviatile alluvial deposit, which was formed before the present valley, separating the east from the west cliff, at a time when the sea-cliffs stood far out in what is now the English Channel, and at a time when the Chalk escarpment forming the North Downs had probably not retreated quite so far north as at present. The escarpment was evidently breached by streams flowing off the downs to the north into what may be called the Battery River, as Upper Chalk Foraminifera have been recognised by Professor Rupert Jones in the calcareous seam No. 5,[*] and the large Chalk flints in the lowest bed would also point to an Upper Chalk origin ; their partial angularity would rather suggest their having been transported by the agency of river ice.

In the more recent brick-earth spread over the Greensand and Gault plain occur remains of *Bos primigenius*, *B. urus*, and *Sus*, *Helix concinna*, *Succinea oblonga*, and other land and freshwater shells.

In 1863, the late Dr. Falconer, V.P.R.S., wrote some notes[†] on the bones discovered in digging the foundation of the Battery at Folkestone, now in the Museum of the Geological Society, and mentioned a section of the beds made by Lieut. R. Vetch, R.E., consisting of made earth 6in. deep. Whitish loam, used as brick-earth, 4ft. 6in. to 7ft. 6in. Marl and flint gravel, with fossil bones, 18in. thick. The latter Dr. Falconer described as unrolled and as all being of the same mineral condition, and as belonging to the following species:—*Hippopotamus major* (*humerus*, anchylosed *right radius* and *ulna*, *right scapula*, *axis*, and three *cervical vertebræ*). *Cervus megacerus*, *Rhinoceros* probably *R. leptorhinus*, *Elephas*, sp. doubtful (*E. primigenius*, and *E. antiquus* occur at Folkestone). *Bison priscus*, *Cervus tarandus*, *Bos priscus*, *Sus* (rolled lower jaw). To this list Professor Boyd Dawkins adds the following species:—*Cervus elaphus*, *Rhinoceros tichorhinus*; and in Mr. Mackie's list, is also *Hyæna spelæa*.

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[*] Mackie "On Folkestone Elephant Bed" (Quart. Journ. Geol. Soc., Vol. vii., 1851).

[†] "Palæontological Memoirs, and Notes of the late Hugh Falconer, A.M., M.D," Edited by C. Murchison, M.D., F.R.S., p. 564.

SOUTH COAST.—Professor Prestwich, in 1864, expressed his opinion that the break between France and England was not the result of the last geological change, but that the Channel had existed certainly during the period of the formation of the low-level gravels, and possibly during that of the high-level, of the Thames and Somme valleys.

In the Sangatte* raised beach he found in 1865 two pebbles of red granite, probably from Cotentin, and various fragments of the Oolitic series of the Boulonnais, which he considers affords additional support to his view of an open channel to the westward. Above the beach are 20 to 80 feet of loam, chalk, and flint rubble, with land shells (Loess).†

An examination of the Admiralty Charts of the English Channel shows that there is no part of the English Channel, near either of the lines of the proposed Tunnel, deeper than 30 fathoms, which is 5½ fathoms less than I found Lake Windermere, in Westmoreland, to be on sounding it last year. The great probability that the anticlinal axis of the Weald formerly extended across the Channel to France, and marked the old water-shed, renders it almost certain that streams flowing north, towards the prolongation of the Thames, would probably have not cut their valleys very deep, and that the chance of filled up fissures being met with is exceedingly small.

The Brighton raised beach has been so often described since the days of Martin, Mantell, and Murchison that it is almost needless to recall its characteristics. In 1859 Professor Prestwich traced it past Arundel to Chichester and Bourne Common, and showed that though at Brighton it was only 8 to 12 feet above the present level of the sea, at Arundel it was 100 feet, and at Bourne Common, 42 miles distant, it was 140 feet. Ten miles west of this point Professor Prestwich showed, in 1871, that at the top of Portsdown Hill, at an elevation of 125 feet, and 85 feet above the angular ochreous gravel of Chichester, Havant, and Portsmouth, there is a true shore deposit, 4 to 6 feet in thickness; in the earthy bed above it occurred a rough flint implement.

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* "Additional Observations on the Raised Beach of Sangatte." Quart. Journ. Geol. Soc., 1865.

† "On the Loess and Quarternary Beds of the North of France and South East of England." Phil. Trans., 1864, part ii.

In the valley of the Avon in Hampshire, Professor Prestwich describes several terraces of gravel, respectively 30 to 70 feet, 150 to 180 feet, and 200 to 250 feet above the river; in the highest, he found some flint implements, near Downton, Fordingbridge (320 feet above the sea). The flint implements of Salisbury, described by Mr. Evans, F.R.S., occurred at 110 feet above the present river; those of Southampton 86 to 150 feet above the river.

The high level plains of the mainland of Hampshire, described by Mr. Codrington, F.G.S., can be traced inland northward to a gravel-capped escarpment 20 miles inland, 420 feet above the sea, and 200 feet above the ground to the north. These plains are all capped with gravels and brick-earths, deposited by rivers when the land stood further out to sea than at present; the continuity of the old valley slopes being broken by the existing narrow valleys, and by the sea-cliffs, capped with the gravel, from 100 to 120 feet above the sea, as between Poole and Bournemouth, in which the flint implements have been discovered at various times. At Barton and Hordwell cliffs the thickness of the gravel is 18 to 20 feet; in 1757 it was described as 18 to 20 yards; and in 1821 as 56 feet, which as the coast wastes a yard a year must have been the thickness of the cliffs considerably in advance of the existing ones, the gravel rapidly thinning inland.*

No organic remains have been recorded from the gravel of the plains, though they occur plentifully in the valley gravels intersecting them, but two flint implements† have been found in the gravel-pits of Southampton Common, at 86 and 150 feet above the sea. The flint weapons in all cases appear to have been derived from the white gravel which overlies the red, and the brick-earth.

Sarsen-stones occur everywhere, and in large size in the gravel between Gosport and Southampton Water, 170 feet above the sea.

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* Quart. Journ. Geol. Soc., 1870.

† Quart. Journ. Geol. Soc., Vol. xiii., p 48.

On the 100 feet plain east of Poole Mr. Godwin-Austin records waterworn pebbles of white quartz, granite, and porphyry; and Mr. Codrington describes white quartz as far east as Lymington, and granite, syenite, and greenstone in the low gravels 27 feet thick of Southsea, which are probably connected with the Brighton Raised Beach. Similar gravels cap the flat-topped hills of the Isle of Wight, from 100 to 300 feet above the sea, and at Headon Hill at 390 feet, the sole remaining portion of an old table-land sloping northwards towards the main land. No organic remains occur, though they are plentiful in the terrace gravels, high up the sides of the present valleys.

The immense antiquity of palæolithic man as stated by Sir Charles Lyell, is nowhere better shown than in Hampshire, from the clearness of the evidence of the changes that have taken place in the contour of the valleys and the outlines of the sea coast, and from the excessive denudation of Cretaceous and Tertiary strata since man's advent.

Professor Prestwich, in his paper on "The Quarternary Phenomena in the Isle of Portland and around Weymouth (Quart. Journ. Geol. Soc., 1875), after giving an elaborate description of the various Drift deposits of the districts, including the Portland Mammaliferous Drift, which occurs about 400 feet above the sea, and contains large blocks of sarsen-stones, *Elephas antiquus*, &c., states his opinion, that, about the close of the Glacial Epoch, before the present valley systems were elaborated, "a broad tract of Chalk, bounded in places by Greensand, and capped by Tertiary beds and older gravels rose inland;" . . which "were brought into level juxtaposition by and along the great line of fault running westward and eastward nearly midway between Dorchester and Weymouth." From this area the ground sloped southward to the termination of the Isle of Wight, the plain of Weymouth not having as yet been excavated, and that rivers ran over this surface, one of which carried the detritus, and mammalian remains found in the Mammaliferous Drift.

The coast line from Cornwall to the south end of Portland had probably fewer deep bays, and ran straight from headland to headland; eastward it trended inland by Fareham and Chichester, and cut the present sea coast at Brighton. Then, as now, the shingle drifted from west to east, while floating ice may have transported the larger masses on the Sussex coast from more distant localities.

In the meantime Professor Prestwich* believes "an east and west anticlinal disturbance elevated the Weymouth district, and with it part of the Purbeck and Portland area succeeded or accompanied by a denudation which not only levelled but deeply channelled the uplifted areas." After which various angular land *débris* and loam, Greensand drift, high-level and low-level gravels, were deposited.

The Mammaliferous Drift Professor Prestwich correlates with the Portland raised-beach which is 24 feet above the present beach at the Bill, rising to 53 feet at its north-eastern extremity. Of the 28 shells occurring in it all but one, according to Mr Gwyn Jeffreys, are now living in the British Channel, but all have a more northern range, and *Cyamium minutum*, a small Greenland shell, occurs in thousands.

The loam, head, or talus, lying at the top of the old beach, is evidently of sub-aerial, and, as Mr. Godwin-Austin says, describing these beds at various points in the English Channel, Channel Islands, and the coast of Cotentin, "the materials are always local in origin," while he believes them to have been formed when, through elevations of great amount, the higher tracts of "the country were regions of excessive cold," the low areas were subjected to great cold though not perhaps of a glacial nature.

SOUTH WEST COAST.—Mr. Godwin-Austin, as far back as 1837, showed that there were river terraces in Devonshire. Two years later Sir Henry De la Beche, described the raised beaches occurring round the coasts of Cornwall and Devon, some of which had been noticed by Borlase in 1758, their height above the sea, varying from 12 to 50 feet, formed probably during the same period as the marine silt found in the valleys of the Otter and Exe, first noticed by Mr. Godwin-Austin.

Sir Henry De la Beche appears to have considered the raised beaches to have been formed after the submarine forest period, but it is more probable, correlating the submarine peat beds occurring at Tor Bay, Mounts Bay, &c., and in the Bristol Channel, with those of Lancashire, that the raised beaches are of older date, and belong to that set of conditions which threw down the Presall Shingle in Lancashire, and the Brighton raised-beach; and indeed

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* "On the Superficial Accumulations of the Coast of the English Channel, and the changes they indicate," Quart. Journ. Geol. Soc., Vol. vii., p. 118, 1851.

Sir Henry describes the great peat deposits of the Bridgewater Levels as resting on old sand, mud, and shingle, which rise up through the peat as pointed out by Conybeare and Dr. Buckland, and which are now known as the Burtle Beds.*

It may be well to notice that marked peculiarity of some of the Cornish alluvial deposits, the occurrence of stream-tin, which invariably lies at the bottom of the alluvium, and is even often forced down into chinks and crevices of the rocky floor, locally called the *shelf.* It is easy to understand how readily, as pointed out by De la Beche, veins of oxide of tin occurring in decomposed granite would get broken up, rolled into pebbles, and deposited in the alluvium by the streams, in which by their superior weight more than twice that of granite, the pebbles would soon come to rest and go to the bottom.

De la Beche gives the following section of the stream-tin works of Pentuan, observed by Mr. Colenso:—

	Ft.	in.
1. Rough River Sand, and Silt, mixed with Sea Sand, at the bottom of the deposits, stakes for a foot bridge occurred at the level of low-water	20	0
2. Sand, Timber Trees, bones of Red Deer and Whale, and Human skulls . . .	20	0
3. Silt or Clay, 2 feet. Sand with sea shells 4in.	2	4
4. Silt, lead-coloured in places, shells, horns, bones	10	0
5. Dark Silt, Moss, Leaves of Trees, &c., 48 below high-water mark	1	0
6. Tin Ground. Roots of Oak and other trees, at the top, some with oysters attached to them	3 to 10	

In several other sections given, charred wood, human skulls, and wood cut with an axe occur in the bed immediately overlying the tinstone bed, which, compared with the alluvial deposits of Lancashire, appears to occupy the horizon of the large river gravel at the base of the ordinary alluvium of the lowest plain, which is probably nearly synchronous with the West Lancashire post-Glacial marine beds.

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* "Report on the Geology of Cornwall, Devon, and West Somerset." London, 1839, p. 416.

On the Cornish Coast there would appear to have been a deposit of marine silt after the growth of the peat, on the tin-stuff, in the estuaries, and of peat and alluvium in the valleys, corresponding with the *Scrobicularia*-clays resting on the peat in the West Lancashire plains, and the fluviatile alluvium in the valleys. Mr. Belt has pointed out the remarkable fact that all the areas in the world in which stream-tin and alluvial gold occur, are regions which have never been glaciated. Glaciation, he considers to have swept away any traces of these metals in various countries where they once must have existed, and it is important to note the absence of anything like glacial detritus in the Cornish and South Devon tin area; and he points out the striking support given to this view by the presence of the Norman flora at the present time in that area, which no doubt existed there before the Glacial Epoch, and managed to live on, though doubtless numerous species succumbed. Professor E. Forbes speaks of it as being more ancient and more southern in character than the Kentish flora, itself older than the Germanic in Britain.

THE FRENCH COAST OF THE CHANNEL.—The Somme valley between Amiens and Abbeville is about a mile across. At the top of the plain, on either side, is the upland loam without shells, and hanging on the higher slopes is the high-level gravel, about 30 feet in thickness; beneath this is a terrace of low-level gravel, with elephants' bones and flint-tools, and still lower the alluvial plain, which consists of 20 to 30 feet of peat resting on gravel. It will be at once apparent how close is the resemblance to the sections of the Lancashire rivers, where terraces of gravel fringe the side of the valleys, and peat occupies the lowest horizon but one of the alluvial plain.

The great beds at the mouth of the Somme extend out seawards, and prove that the valley formerly extended out into the British Channel. Near the surface of the peat occur Gallo-Roman remains, and at greater depths neolithic weapons, as is the case in the peat section on the Cheshire coast. In the basement beds of the low-level Somme gravels, *Cyrena fluminalis* occurs, and some marine shells mixed with the freshwater forms.

In the high-level gravels of the Seine, near Paris, Professor

Prestwich found traces of ice-bearing action and contortion of beds, as in the high-level Amiens beds. All the fragments found in the basin of the Seine belong to rocks in that area, but the great size of some of the travelled blocks of granite point to floating river ice. One of these blocks, now in the Ecole des Mines, is stated by Sir Charles Lyell to be nearly 4 feet in diameter. In 1862 M. Lartet discovered in the low-level gravels of Clichy flint implements of the Amiens type, associated with remains of *Elephas antiquus*, and *E. primigenius*.

CONCLUSION.

It has been shown that in the case of the river Ribble a wide and extensive valley has been cut out entirely since the deposition of the Upper Boulder Clay, that terraces fringe the sides, and that peat beds occur near the bottom of the lowest alluvium, which are continuous with extensive peat beds underlying the sea level, and yet resting on post-Glacial marine beds, proving that the land was lower after the Glacial Period and the formation of the terraces than it is at present, and that afterwards it became higher, when neolithic man emigrated from more southern districts over continuous land.

In the Irwell still more extensive denudations had taken place, and wider terraces formed, peat again occurring near the bottom of the alluvial plain.

In the Ouse also occurred high-level gravels, lying in a valley excavated out of the Boulder Clay, and in these are found palæolithic flint weapons.

In the Thames basin Boulder Drifts were shown to be present, reaching down nearly to the valley, which abruptly cuts them off, and in which are deposited various high and low-level gravels, the former with palæolithic remains of human art, there being the strongest reason to believe that the whole of these terraces, like those of the northern valleys, were formed since the deposition of the Glacial deposits, during which period the Weald district remained an island above water, and extended much further out into the English Channel than at present, the Battery River at Folkestone flowing eastward over this old plain.

At a later period the valleys were cut down, modern alluvium formed, with peat and submerged forests at the base, both on the south and west coasts and in Northern France, where a similar sequence from the palæolithic gravels to the peat era obtained;

but, as proved by the French coast-beds with sea-shells, there was an episode of subsidence, as in England, as proved by the Sussex raised-beach, the Burtle-beds of Somersetshire, and the Shirdley Hill Sand of Lancashire; at the same time rivers higher up on the land were depositing the massive gravels, and in Cornwall the tin-stone beds found beneath the peat. After the obstruction of drainage caused by elevation, that produced the peat, gave way, the country subsided a little, and the relative levels of land and sea have remained tolerably constant since the Roman era.

VISIT TO THE MINERALOGICAL DEPARTMENT OF THE MUSEUM OF PRACTICAL GEOLOGY.

MARCH 22ND, 1875.

Director—F. W. RUDLER, ESQ., F.G.S., Dir.A.I.

(*Report by Mr. Rudler.*)

Before commencing the inspection of the Mineral Collection, the Director explained the principal systems which have at various times been proposed for the classification of minerals. He contrasted the natural-history method of Mohs and his school with the chemical methods of Berzelius and his followers, and remarked that after Berzelius had founded a system in which the electro-positive element formed the leading characteristic, he was led, by Mitscherlich's discovery of isomorphism, to construct a new system in which the electro-negative element was the basis of classification. It was argued that a purely chemical and crystallographic arrangement, though of great value scientifically, scarcely satisfied the requirements of the geological student and the practical miner; and the mixed system followed in the Museum of Practical Geology was defended as the most useful for such purposes. The minerals containing the heavy metals are arranged in the wall-cases, all the ores of a given metal being grouped together; whilst the minerals which are destitute of metal, or contain only the lighter metals, are placed in the so-called Horse-shoe Case. It was to these "non-metallic" minerals that the attention of the visitors was restricted, special notice being taken of such species as are important as rock-constituents. After the elementary substances carbon and sulphur, had been described, attention was called to those minerals which contain alkaline metals, such as rock salt. The few minerals containing barium and strontium led to the salts of calcium, which include such important species as calcite, gypsum, fluor-spar, and apatite. These were succeeded by a large series illustrating the various forms of silica, and these in turn by a small collection of the varieties of alumina. Then followed the great group of silicates, both hydrous and anhydrous; the latter including some of the most important species to the petrologist, such as the felspars, micas, hornblendes, and augites.

EXCURSION TO THE ISLE OF THANET.—Easter Monday, March 29th, 1875, and following day.

Director—George Dowker, Esq., F.G.S.

(*Report by* Wilfrid H. Hudleston, Esq., M.A., F.G.S.)

The party quitted the Railway Station, at Ramsgate, shortly after 1 p.m. on Easter Monday, and proceeded at once towards Pegwell Bay. Arrived on the shore, Mr. Dowker began the work of the day by pointing out, in the first place, an irregular mass of gravel and brick-earth, generally believed to be of fluviatile origin. It rests, in this place, directly upon the Chalk, and is considered to be of the same age as certain high level gravels resting on the Lower Tertiaries near Herne Bay, in which palæolithic implements have been found. Some geologists have referred its deposition to the Mid-Glacial period, but there seems to be much doubt as to this. A member of the party had recently found both *Buccinum*, and *Ostrea* in the deposit, but whether these got in from above or are really a part of the deposit there is at present no evidence to show.

The Isle of Thanet is a somewhat oval mass, of moderately high ground, separated from the mainland of Kent by a belt of marsh, which though now banked in and drained, has within the historical period been a shallow strait into which the estuary of the river Stour discharged, and which communicated freely with the sea, on the north, at Reculvers (Regulbium), on the south east near Richborough (Rutupiæ). The constituent rock of the Isle is Chalk, which rises in a sort of gentle anticlinal swelling, having an axis with a mean direction, E.N.E.—W.S.W. It falls away also to the westward, whilst on the east its section by the sea prevents us from forming an idea as to how far the axis might be prolonged in this direction. This Chalk of Pegwell Bay is the same as that of Margate, and is the highest in the county, perhaps as high as any in England, the general *facies* of its *fauna* having much resemblance to that of Norwich. It is remarkable for the small amount of flint contained, and this circumstance induced geologists formerly to suppose that this Thanet Chalk was really Lower Chalk. It also contains ammonites, indeed there seems to be some connection between flintless chalk and ammonites, which may be more than accidental. It is to be noted that the ammonites occur in casts; from the appearance of large ammonites, Professor Prestwich was led to conclude that the Kentish Chalk represented the Medial Chalk of England, but their appearance at Dover and Margate in widely separate beds will not warrant this conclusion. The few flints there are appear, for the most part, to be fossil sponges.

There is a slight fault in the cliff at Pegwell Bay, which brings down the Chalk against the Thanet Beds; considerable irregularity in the dip is noticeable, with a balance towards the S.W. There is, however, a very marked southerly dip of the Chalk generally on this side of the Isle of Thanet, in the direction of the Stour marshes, which lie in a well marked synclinal filled with Tertiary beds. Pegwell Bay itself may be viewed as a seaward continuation of this synclinal hollow. The junction of the Chalk and Thanet Sands may be seen in the low cliffs of Pegwell Bay. The well-known green-coated flints, so constant an attendant upon this junction, not only with the Thanet Sands, but with other permeable beds of the Lower Tertiaries, came in for a large share of attention. "It is a peculiar feature of these junction sections of Chalk and Thanet Sands, as seen in East Kent, that the green-coated flints nearly always rest on a semi-tabular mass of Chalk flint." (Dowker in "Geological Magazine," Vol. iii., May, 1866). This peculiarity was well observed on this occasion by the party in Pegwell Bay. The green coating is said to be due to a deposit of hydrous silicate of iron as a sort of glaze.

The lower beds of Thanet Sand, at Cliff End, are very fossiliferous. *Dentalium nitens*, *Natica subdepressa*, *Cyprina Morrisii*, *Cytherea orbicularis*, *Nucula Bowerbankii*, *Ostrea bellovacina*, *Panopea granulata*, *Pholadomya cuneata*, *Pholadomya Koninckii*, *Thracia oblata*, are the most abundant and characteristic species.

There is one bed seen in the low cliffs about 4 inches thick, which is a mass of shells, chiefly *Cypina Morrisii.* This species, with many others, also occurs throughout, sometimes very fine, and in good preservation.

Some of the more active and adventurous members of the party, by dint of scrambling and the use of hammers with long handles, secured really very nice specimens.

At the "Sportsman" (Red Cliff End Point) the ladies fell in, and the whole party, after a hasty luncheon, proceeded in conveyances by a road made along a remarkable pebble beach which extends from the Isle of Thanet almost to Sandwich. At a break in this pebble beach, called Ebsfleet, the Ordnance Map has the following legend, "Here the Saxons first landed." If this be true, and if the conjectures as to Cæsar's landing, subsequently to be mentioned, are also true, then this must have been one of the most vulnerable districts on British soil.

The party dismounted at the Salterns, and crossed the Stour, a sluggish river some 30 yards wide, in which a feeble neap tide was slowly rising. A walk of less than a mile across the marshes, but still close to the river, brought them to the foot of the singular island on which the Roman *castrum* of Richborough (*Rutupiæ*) was constructed. This is an outlier of Thanet Beds, capped by Woolwich Beds: about the junction is a persistent line of *Corbula* and other shells in a silicified condition. The railway to Deal shaves off a portion of this outlier, and whilst the line was being made specimens were easily obtained; not so at present. Mr. Dowker here took the opportunity of again pointing out some of the leading geological features of the district.

He commenced by remarking on the singular fact that, although the Norwich Chalk contained fossils very similar to that of Thanet, yet here we have, immediately reposing on the Chalk, the lowest of the Tertiaries known in England; whereas, in Norfolk, we have for the most part the highest and newest Tertiaries in a similar position. He again also took the opportunity of showing that the existence of *Ammonites*, made so interesting and patent to the Members by the well-known Paper of their Associate Mr. Bedwell, was no longer to be deemed a proof that the Thanet Chalk occupied a lower zone. Speaking of the Tertiaries he observed that nowhere else in England could such low beds of Thanet Sands be seen, and these contained very numerous marine remains. The

Woolwich Beds, of which a cap exists here (pointing to the platform forming the summit of the outlier), were also marine, and less characteristically developed than in the neighbourhood of London, where, as is well known, they are markedly estuarine in character. The President of the Association had formerly determined for the speaker a very remarkable specimen of *Pinites* found about the junction between the Thanet and Woolwich Beds. Alluding now to the remarkable deposits of gravel which occur in East Kent at considerable elevations, both upon the Chalk and upon the Tertiaries, and which contain chip-shaped flints, Mr. Dowker stated his belief that these were of high antiquity. Mr. Geikie considers them to occupy an Inter-Glacial period, and one anterior to the date in which the Boulder Clay was deposited; they occur in the south-eastern portions of England, and he considers their absence further north and west is to be accounted for by their having there been obliterated by the Glacial sea which deposited the Boulder Clay, which latter is not found in the east of England south of the Thames. Geologists are indebted to Mr. Geikie for having in his book, the "Great Ice Age," placed in a clear light the various phases under which Glacial geologists suppose England, Scotland, and Ireland have passed during the Glacial Epoch. The palæolithic gravels of East Kent must have been, according to this geologist, elevated above the reach of this Glacial sea. Kent would thus present to us a very old land surface. From many considerations it is evident that since the deposition of these gravels the Thames must have deepened its bed by 100 feet.

After thanking Mr. Dowker for this address, the party swarmed up the steep sides of the railway cutting, and proceeded to take possession of the remains of Richborough Castle. A low rectangular wall, about fifteen feet in thickness, composed chiefly of flints, encloses a flat quadrangle about five acres in extent, now wholly given up to the plough. A sort of pit towards the middle of the enclosure conducts to a mysterious underground passage, which the more adventurous of the party explored. The view from this isolated table must, on a clear day, be very instructive physiographically, as it commands the synclinal hollow of the Stour marshes, with the great curve of Thanet on the north, and the still bolder swell of the long range of Chalk heights, forming the backbone of East Kent, on the south.

The word of command to evacuate the fortress having been given, the party recrossed the Stour, and on gaining the high road retired upon Margate for the night.

On the following morning the low cliffs of the Margate Chalk occupied the attention of the party for a couple of hours. So much interest in these beds had been excited by the publication of Mr. Bedwell's very original paper on "Ammonite Zones in the Isle of Thanet" ("Proceedings of the Geologists' Association," Vol. iii., p. 217) that the eagerness of all to "spot" an ammonite could only be equalled by a field of huntsmen round a cover on the look out for a fox. Before proceeding to hunt for ammonites it may be as well to note a few peculiarities in this Margate Chalk. For the general vertical section, see J. W. Wetherell "On Some Fossils from the Margate Chalk" ("Proceedings of the Geologists' Association," Vol. iii., p. 192); and, generally, G. Dowker "On the Chalk of Thanet, &c." ("Geological Magazine" for 1870, p. 466).

It would appear that the Margate Chalk has a thickness of about 30 feet; its lower limit may be taken along the line of the three-inch flint band, which terminates the great series of flinty or Middle Chalk. It is soft, and as might be inferred from the appearance of the coats of those who ventured upon fossil hunting, makes good whiting. In purity it is perhaps not quite equal to the Chalk with flints, as the silica is most probably disseminated instead of being collected in masses. Of mechanical sediment there is not very much. The fossils are to a great extent indicated, rather than actually preserved, by ferruginous stains, and to judge from the frequency of these markings, these are plentiful. *Ventriculite* structure is not uncommon; some nice pieces were picked up here and at Pegwell Bay, also *Brachiolites*, *Coscinopora*, and fragments of *Bryozoa*. *Belemnitella* is not unfrequent. The Ammonite Zone was found as indicated by Mr. Bedwell, and as far as may be judged from a very limited walk, the ammonites lie in one stratigraphical horizon, though, as there is a slight curvature in the beds, the height of this line varies. Thus the first ammonite discovered could only be assailed by missiles from below. The next one found was at a more convenient height, and a terrific onslaught was immediately made upon the prostrate monster by several hammers at once. These ammonites are probably compressed externally, and existing only as casts, are not easy to study with a view to the determination of the species. If there is any truth in Ammonite Zones, that is to say in particular species being confined to particular zones, it is rather surprising that names applied to Lower Chalk forms, such as *A. Lewisiensis* and *A. peramplus*, should also be quoted for ammonites in such high beds as the Margate Chalk. It is true that in extreme old age indifferently preserved specimens of large ammonites, occurring as casts in calcareous beds, have a strong family likeness.

The *Ammonites leptophyllus* of Sharpe, quoted as occurring in the Upper Chalk of Brighton, Ramsgate, Greenhithe, &c., is probably the nearest to, and may actually be the same as the Margate species. "This species reaches a diameter of more than 2½ feet; in shape it is discoidal, flattened at the sides, and rounded at the back." (Pal. Soc. "Chalk Cephalopoda," p. 48.) This description answers roughly to the specimen in the cliff, which some of the party were bringing out piecemeal. The diameter of the outer whorl of this specimen must have been upwards of three feet; many fragments of the middle whorl were obtained, and also a portion of a little inner whorl with some of the shell on—a rare circumstance in the Chalk. This inner whorl, which is only in a fragmentary condition, has the back very round, and the sides much compressed, with faint indications of numerous costæ of little elevation barely reaching the centre of the back. The figure given by Sharpe (Pal. Soc., "Chalk Cephalopoda," plate xxii.) might very well represent the middle age of such a specimen. Much interest naturally attaches to these ammonites, which occupy the highest position of any members of that great genus, so characteristic of the Secondary rocks. On or about this horizon—in England at least—they seem to bid farewell to the palæontologist.

Proceeding westward along the foot of the cliffs, an appearance like the weathering of decomposing basaltic dykes is very conspicuous; this arises from the wearing away of the cliff along a series of joints, which seem mostly in a north-west and south-east direction, or about at right angles to the plane of bedding, and almost perpendicular to the mean direction of the Thanet axis. Near a place where the new Aquarium is to be constructed, a very singular group of fossils was discovered. These consisted of a number of bags of cement, from a shipwrecked vessel; the cement, bag and all, had set under water, and was now in the condition of hard rock. This assumed exactly the shape of the bag, down to the very corners. The impression of the sacking produced an appearance like *Stigmaria*, and the seam of the bag, in one or two instances, was perfect.

The midday train was now taken as far as Herne Bay, whence the party proceeded in carriages to Old Haven Gap.

Here Mr. Dowker pointed out the beds in ascending order, from the base of the cliff looking towards Herne Bay; first the Woolwich Beds, resting at or near a junction with the Thanet Sands (for the division was very obscure); these are here capped with a thin band of pebbles which mark the junction of the Old Haven Beds of Whitaker, and the top of this series was shown by the coming on of the London Clay, here very unfossiliferous. Proceeding towards Herne Bay a short distance, the excursionists followed this Old Haven Bed as it descends to the beach, where its presence is marked by the layer of lenticular sandstone masses stretching out like a pier into the sea. Retracing their steps, they proceeded beneath the cliff towards Reculvers, Mr. Dowker pointing out the Thanet Sands and the Woolwich Beds, and the excursionists making hasty attacks on the tempting fossils exposed in great profusion beneath their feet, but which required far more time for safely securing than the rapid march, necessitated by their having to catch a train, allowed.

Towards Reculvers the tabular masses of sandstone are most abundant at the base of the cliff, and form a floor to the beach; they constitute the horizon in the Thanet Beds seen towards the top of the cliff at Pegwell Bay; these and the Reculver sections representing the entire series of the Thanet Beds. A short walk brought the party to Reculver Church, where the position of the Roman Castrum—the Regulbium of the Romans—was pointed out, and a few remarks on the antiquity of the original church, its probable Saxon if not Roman origin, and its connection with Richborough and its historical interest were dwelt upon by the Director of the Excursion. Reculver is given by Sir Charles Lyell as an instance of the ravages of the sea, but Mr. Dowker pointed out that the parish authorities need not have been in such a hurry to dismantle their beautiful church, for the sea had certainly not gained on the shore lately, and a deposit of sand appears to show it did not attack so fiercely the present shore.

From this point the party resumed their seats in the carriages to return to Herne Bay.*

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* Consult "Proceedings, Geologists' Association," Vol. i., page 339, *et seq.*: also Whitaker, "The Geology of the London Basin," "Memoirs of the Geological Survey of England and Wales, Vol. iv., p. 372.

ORDINARY MEETING, APRIL 2ND, 1875.

WILLIAM CARRUTHERS, Esq., F.R.S., F.LS., F.G.S., President, in the Chair.

The following Donations were announced :—

"Abstracts of Proceedings of the Geological Society;" from that Society.

"Proceedings of the Warwickshire Naturalists' and Archæologists' Field Club," 1874 ; from that Club.

"Journal of the Society of Arts," Feb., 1875; from that Society.

"Journal of the Winchester and Hampshire Scientific and Literary Society," Vol. i., part 4 (1874); from that Society.

"Annual Report of the Brighton and Sussex Natural History Society," 1874; from that Society.

"Journal of the Society of Arts," March 1875; from that Society.

"Procedings and Transactions of the Nova Scotian Institute of Natural Science," Vol. iii., part 3 (1872-3); from that Institute.

"Geological Structure of the South Staffordshire Coal Field," by J. Beete Jukes, M.A., F.R.S.; from W. Whitaker, Esq., B.A., F.G.S.

"The Industrial Geology of Bradford," by John Brigg; from William Whitaker, Esq., B.A., F.G.S.

"On a Railway Section of the Lower Lias, &c., near Stratford-on-Avon," &c., by Rev. P. B. Brodie, M.A., F.G.S.; from the Author.

"Sur la Craie de l'Ile de Wight," par M. Charles Barrois ; from the Author.

"Sur le Gault et sur les couches entre lesquelles il est compris dans le bassin de Paris," par M. Charles Barrois; from the Author.

"Sur les Brachiopodes Tertiares de Belgique," par Thomas Davidson, F.R.S.; from the Author.

The following were elected Members of the Association :—

The Rev. W. H. L. Cogswell, M.A.; Douglas Duncan, Esq., Advocate; Ernest Spon, Esq., Mining Engineer; and C. Herbert Stokes, Esq.

The following Papers were read :—

1. On Geological Boundary-Lines.*

By Horace B. Woodward, Esq., F.G.S., H.M. Geological Survey.

The steady progress of geological knowledge leads us from time to time to make important alterations in our Table of British Strata. Fresh subdivisions are occasionally made, and new observations sometimes lead to a different classification of old and recognised divisions. When we compare the tables constructed by geologists in the early part of this century with those now in use, and when we consider the reason why many subdivisions are made, and why certain boundary-lines have been fixed upon, we cannot but discern a tendency to overlook the broad classification by mineralogical or lithological characters, and to adopt as lines of demarcation those essentially of a palæontological nature. The discussion of this subject is all the more necessary when the question of geological mapping is taken into consideration.

All those acquainted with field-work, and the tracing of geological boundary-lines, must be aware that so far as the actual guides are concerned in constructing the map, palæontology plays a very insignificant part. Nor could it be otherwise, as for the proper collection of fossils they must be obtained *in situ*, while the rarity of fossils in some formations, and the paucity of sections in others, preclude any purely palæontological boundary-lines being traced satisfactorily. At the same time the value of geological maps cannot be over-estimated, furnishing, as they do, indexes to the geology of a country; and when they exhibit the chief lithological divisions, without perhaps marking continuously all the deposits of one exact period of time, little more can be expected from them.

There is no need to discuss the variability of geological formations and their included fossils: that any kind of sediment and many varieties of organic remains may be deposited and accumulated at the same time, is patent to every observer; and similarly, that the organic remains are liable to variation according to the nature of the deposit in which they were entombed, this indicating different depths of water and other sedimentary conditions. Thus, in a formation of one age, the lithological characters and fossils may vary to a considerable extent, as in the Woolwich and Reading

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* It was suggested during the discussion of this Paper, that its proper title would be "The Difficulties of a Geological Surveyor."

Series. Hence the importance of adopting, as a rule, terms expressing no distinct mineral character. At the same time taking the formations themselves into account, we naturally find that the chief variations are in the shore deposits, and that these are necessarily of small extent compared to those of deeper water, which are more persistent. Further, as the character of the deposits and the depth of water equally affect the organisms existing at the time, they might be expected to coincide with the evidence of the rocks, except that great allowance must be made for the drifting and entombing of organic remains away from the spots where they flourished.

In subsiding areas, where shallow-water deposits are succeeded by those of deeper water, we may naturally expect a repetition of similar forms in deposits of different age, species migrating from one area to another, in order to obtain conditions suitable to their welfare. The identity of organic remains can never afford absolute proof of contemporaneity, whether in the minor divisions at home, or in the grand divisions abroad.

Geologists, familiar with our British rocks, may generally recognise a formation when a good exposure is shown, whether in a railway-cutting, quarry, or cliff-section, or they may determine its age by working out its relations to other rocks in the neighbourhood. But supposing a geologist to be placed without any previous knowledge of the district in a clay-pit, he might very easily be perplexed in determining whether the beds be Gault, or Kimmeridge Clay, or Oxford Clay, and here the discovery of one or more fossils might determine the question at once. In the same way he might be puzzled with certain sections of limestone, sandstone, or slate. From mere hand-specimens of rock or pebbles, it is generally hazardous to express a definite opinion, although, at the same time, many such specimens could be picked out with characters peculiar to the rock, and therefore determinable. Palæontology here would afford often a ready clue. In these cases, as in specimens obtained from well-sinkings and deep borings, both lithology and palæontology must check one another.

In identifying the age of a formation, the test of superposition or its stratigraphical relation to other deposits is, as a rule, decisive. Palæontology must spring from stratigraphy. Show a fossil or a set of fossils (not common species) to a Palæontologist, and he will probably ask whence it comes before naming a specimen.

It must not be supposed that I wish for a moment to detract from the importance of palæontology, but the main facts of palæontology in their application to the identification of strata must first be worked out from the stratigraphical succession of the rocks, before the results can be applied as a key to isolated or disconnected portions of rock. Then geology and palæontology will go hand in hand.

Although strata may be identified by stratigraphical position and by fossils, Professor H. G. Seeley has pointed out that no satisfactory classification of rocks can ever be made by fossils, and that no classification true for any large area can be made on mineral character; but he considers that strata can be identified and correlated by discovering the physical conditions which limited, determined, and changed their mineral characters, and changed the distribution of the fauna and flora of the given geographical area which they occupy.* The value of Palæontology cannot indeed be disputed, and if we cannot identify formations far separated as synchronous when the fossils are similar, as Edward Forbes first taught, we may still parallel successive faunæ as Barrande has done.†

Professor Agassiz once expressed the opinion that the rocks should be regarded merely as the tombs of the fossils, that naturalists should try to find out the animals of an epoch, and establish the limits of faunæ on zoological and not on physical principles.‡ To this Professor W. B. Rogers replied to the effect that faunæ are not unfrequently mingled in contiguous formations, that they do not hold the same precise geological level or vertical distribution at different localities, that they may even become inverted in relation to each other, offering in this and other cases evidence of emigration and re-migration in successive times; and he maintained that the precise and absolute limitation of faunæ to formations, as advocated by Professor Agassiz, if true in any case, is at best but of local and partial application, and can not be the basis of a palæontological arrangement of formations. Even according to the ordinary and much less stringent view of geological faunæ, Professor Rogers observed that only the few great divisional lines of the geological column are persistent over extensive areas, while the numerous subordinate ones, however distinct at the typical locality, lose themselves as they are traced, to give place to other modes of subdivision.*

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* "Annals and Magazine of Natural History," for December, 1867.

† See Barrande, "Observations sur les Rapports de la Stratigraphie et de la Paléontologie." Bull. Soc. Géol. de France, 2e Série, Tome xi., p. 311.

‡ "Proceedings, Boston Society of Natural History," Vol. vii., p. 241.

Our British geological formations have been generally described, and their boundaries defined from so called typical sections, and from such we gain ideas which are not unfrequently confused when the same formation is viewed in a locality removed from the original type. Thus, the terms of Greensand and Carboniferous Limestone, although true for some localities, are calculated to puzzle and foster erroneous ideas. On the other hand, the terms Crag, London Clay, Chalk, Lias, and Old Red Sandstone, are applied to formations whose chief characters, indicated in the names, are persistent over large areas, and no great fault can be found with them.†

When we come to consider some of the subdivisions, many difficulties arise. Some of these have quite a local development, and are yet sufficiently important to require separate designation. It is not always easy, nor possible, to insert them in their proper place in chronological order with the larger divisions, which, of course, they in part replace. We might say that a portion of the Great Oolite was of Fuller's Earth age, or *vice-versâ;* that the Midford Sands were sometimes of Upper Lias age, at others, of Inferior Oolite age; even that the Middle Lias was sometimes of Upper Lias age, and this because Middle Lias conditions prevailed longer in one area than in another, so as to be contemporary with Upper Lias forms of life and deposits in a distant part. The Oolitic series, as a whole, consists of sandy and clayey strata with great lenticular beds of limestone. When traced from Dorsetshire into Yorkshire it is found that three, if not four, different classifications of the rocks, based essentially upon lithological characters, must be made at different localities. It would be difficult, and I should consider it impossible, to correlate these divisions in regard to time with any great accuracy; it is sufficient to say that such and such beds are "homotaxeous."

The Greensand of the borders of Dorset and Devon may represent parts of the Upper Greensand, Gault, and even Upper Neocomian, and yet it constitutes one physically connected series, and it would neither be possible nor profitable to trace out or map the palæontological divisions that have been made in it.

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* "Proceedings, Boston Society of Natural History," Vol. vii., p. 234. See also pp. 246, 273.

† See paper by J. W. Judd, F.G.S., "Geological Magazine," Vol. vii., p. 220.

The same might be said of the Speeton Clay, which consists of a series of clays attaining a thickness of over 500 feet. According to Mr. Judd's observations, the beds represent the Upper Neocomian (Lower Greensand), Middle and Lower Neocomian, Portland Beds and Kimmeridge Clay. In his opinion no portion of the series can be identified palæontologically with the Gault; and at the same time he points out the probability of there being an unconformity between the Neocomian and Jurassic portions. Of course, in mapping the beds, it would be advisable to separate the Neocomian and Jurassic strata, but it is questionable whether this or any of the palæontological divisions could be traced out with any great approximation to truth, supposing them to extend over any considerable tract of country; and should there turn out to be no real unconformity in the series, it would be far more just to map it all under the denomination of Speeton Clay; a plan which would not for a moment be calculated to set aside the great importance and interest attaching to the natural history of the beds, which has been so carefully worked out by Mr. Judd.

As an instance of a palæontological boundary-line, the junction of the Lower and Middle Lias may be mentioned. So far as the south-western counties of England are concerned, there really is no line of division at all, as the beds pass into one another without any break. The old divisions, in which the main masses of clay and limestone were separated, were much better, and certainly more important so far as a geological map is concerned.

In Buckinghamshire, Lincolnshire, and Norfolk, and probably in Sussex, the Kimmeridge and Oxford Clays come in direct sequence. Unless we imagine an unconformity—and there is no reason for this supposition—the Coral Rag and Calcareous Grit developed in Oxfordshire, Wiltshire, and Dorsetshire, are represented by portions of the Oxford and Kimmeridge Clays in the districts just mentioned. In these cases the divisional line must be made, if at all, by palæontological evidence, in which no very great approach to accuracy can be expected.

The history of the classification of the Cambrian and Silurian rocks shows how liable to change is any boundary-line fixed by the occurrence of organic remains. Professor Hughes, in discussing a paper by Dr. Hicks on the Arenig and Llandeilo groups, recently read before the Geological Society of London (Dec. 2, 1874), observed that the fossils by which the rocks were subdivided did not occur all through the several groups, but only in widely separated zones, and that between those zones, sometimes one line and sometimes another, had been taken as the arbitrary boundary, often to be shifted in consequence of the discovery of other fossiliferous bands. He is strongly of opinion that geologists should adopt Sedgwick's old classification of the Cambrian and Silurian rocks. A well-marked lithological boundary-line, as the Director of the Geological Survey of England has often remarked to me, cannot be displaced; whereas a purely palæontological boundary-line is ever liable to change.

The Trias of the south-west of England may represent the Bunter, Muschelkalk, and Keuper, and yet it is not possible to mark out these divisions to correspond with any degree of certainty with those made on the Continent, and all that can be done is to map the separate lithological divisions. My colleague, the Rev. J. H. Blake, F.G.S., when carrying on the Geological Survey in West Somerset, came to the conclusion that the Muschelkalk was there represented, and during an examination of the country with him, he pointed to the particular beds which from position and mineral character he classed with this formation. My own opinion is, that it is impossible to say by which particular bed, or set of beds, the Muschelkalk is represented, but that there is no reason to consider its absence as indicative of any break, because in Devonshire the Triassic beds exhibit no unconformabilities, and because the sedimentary conditions must have varied considerably in different areas.

Again, so far as geological mapping is concerned, it would not be possible to identify and make a map of every deposit of Gault age in England, or of Upper Lias age, or of Keuper age, or indeed, strictly speaking, of any deposit, seeing that changes in sediment and in organic remains are not likely to occur uniformly over an extended area, and it is impossible to state with precision where in time one deposit was represented by another dissimilar. In fact, our terms are mere convenient forms of expressing an idea; an observation which has been frequently made.

Our formations, then, must be taken to represent deposits of essentially similar character when looked at in a large way, and characterized by a particular assemblage of fossils. They may become attenuated in places, and there represented in part by different formations. In the case where a formation thins out, or becomes attenuated, we must still apply its name to it without taking in part of the overlying or underlying deposit, even if palæontology seemed to warrant it; for this latter plan would tend to create endless confusion in our geological maps, and in our tables of strata. It is as hard, I might say as impossible, to determine which is a typical section, as which is a typical species or type from which slightly divergent forms are termed varieties.

It must not be supposed that I should imagine an attenuation to represent necessarily a lesser time for its formation than a greater thickness of a rock. Of course the rate of deposition of sediment in a given area may be liable to much modification, some portions for a time may even be without sediment. Nevertheless there can be no reasonable doubt that many of our geological formations are in part represented by other formations in distinct or distant areas; and yet by palæontological evidence we can seldom draw definite lines of demarcation. Our geological classification, so far as the limited tract of Britain is concerned, must be mainly constituted on lithological evidence; and our formations, as recognised and delineated on our maps, must be simply regarded as the expression of certain physical conditions which maintained over a certain area, and as belonging to a sequence which probably varied to a considerable extent in the extension and duration of its many members. By confining, as far as possible, the use of our geological terms to certain deposits—the evidence of certain physical conditions—we may obtain more uniformity, and a stability in our tables of strata, that will not be found if the divisional lines be fixed by palæontological evidence.

The more we learn of the history of our strata, and those of foreign countries, the less evidence do we see of breaks in the conformity of succession. Of course there are gaps that we can never expect to fill up in our own island. But looking at the general results of geological knowledge, as applied to the succession of strata, and finding many easy transitions in rock-character and fossils, we need not be dismayed that our boundary-lines appear indefinite, and that correlation appears less exact. The case becomes only parallel with that of the organic remains themselves, where species once held to be distinct are now found to merge one into the other by insensible gradation, and not only species but genera also. In the West of England there is a transition from the uppermost Silurian strata through the Old Red Sandstone and Lower Carboniferous rocks into the Coal Measures—each division may readily be traced out on the ground, and yet it is impossible to point to a particular bed and say, "Here is the junction!" The strata merge one into the other as do the colours in the rainbow, and yet looked at in a large way they are distinct. It may with truth be argued that both lithological and palæontological boundary-lines would be likely to vary in different localities, but whereas the palæontological boundary-line would be always liable to change from fresh discoveries, the line drawn in reference to lithological characters would always hold good.

In conclusion, I may state that, in bringing forward this subject for discussion, I am actuated by the idea that this course will be profitable to myself, and perhaps to many other Members of the Geologists' Association.

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2. ON THE PROBABLE DEPTH OF THE GAULT SEA.

By F. G. H. PRICE, Esq., F.G.S., M.A.I., &c.

Some months ago it was suggested to me by Professor Morris that I should endeavour to discover the nature of the Mollusca, more particularly the Siphonostomes and Holostomes, of the Gault which are peculiar to restricted horizons, as by that means we should be able to ascertain under what conditions the beds were deposited. In this paper it is my desire to shew, as far as is possible, by examining the habits and habitats of existing genera, more especially those which are probably the lineal descendants of the Cretaceous forms, the nature of the Gault Mollusca. At the same time we must take it for granted that their habitats and mode of life, so to speak, were similar, if not identical, with the habitats and mode of life of recent molluscs. I have taken Mr. Gwyn Jeffrey's "British Conchology" and Woodward's "Manual of the Mollusca" as my text books and authorities to furnish me with the required data as to the depths and conditions of the sea in which the various genera have been met with. It may be inferred from physical as well as from biological evidence that the Gault was deposited in a sinking area, *i.e.*, in an area which sank more rapidly than the detritus accumulated, whereby the actual sea bed was deepened. We may safely conclude that most deposits have taken place in a sinking area; but if the accumulation of sediment equals the degree of depression, nearly the same level relative to the surface is maintained by the sea bottom. In saying in a gradually sinking area, I speak advisedly, as I have frequently found large species of *Ammonites rostratus* in the Upper Gault with the shell on, and without any appearance of having been rolled, having *Plicatula* and *Anomia* of large as well as small size attached to them; thus showing that the sea was tolerably quiet, and the deposition of the sediment slow, to have enabled these adhering molluscs to grow and live before they were finally buried; unless they became attached to the living shell when in a larval state.

Commencing from Bed I. (described in my paper "On the Gault of Folkestone," read before the Geological Society, April 29, 1874), the forms met with are for the most part littoral species, and as we get higher up in the deposit we find Laminarian, Coralline, and deep-sea forms gradually coming in. The lowest layer of Bed I. was formed during erosion, when the sea bottom was probably swept by strong denuding currents running at a considerable depth, or following a period of upheaval. This conclusion is arrived at by examining the mineral characters of the fossils obtained. The first foot consists of sulphuret of iron in the form of nodules resulting from the decomposition of organic matter. This is followed by a band of nodules containing a large quantity of casts of *Ammonites interruptus* and other fossils much broken up and rolled. Upon many fragments of the ammonites, species of the family *Ostreidæ* are frequently observed, indicating their contemporaneousness with the formation of the bed, *Anomia* sp., *Pecten quinquecostatus*, and *Plicatula pectinoides*, are species very well preserved. The rolled specimens are possibly derived species, and were fossils before the formation of this deposit. The sea bed then probably began to sink, since we find a seam of greensand coming on, which gradually goes off into clay, and many littoral and shallow-sea forms make their appearance, snch as *Nucula*, *Natica*, *Pholas*, and *Trigonia;* or that it was probably a muddy estuary rather than an actual shore; or if not an estuary, a mud bank some little way off land. As far as the remains of Cephalopoda go, it is very difficult indeed to speak as to their habits, especially as regards *Ammonites* and *Hamites;* suffice it to say they are met with throughout the deposit, and that they were carnivorous, and probably went wherever Mollusca were to be met with, as the living representatives of this great Class do at the present time. Take it for granted that all the lines of nodules represent periods (more or less vast, possibly equal in time to many feet of strata), during which denuding currents swept the area in question. My friend Mr. Hudleston informs me that it has often been suggested by those who have studied the Cambridge phosphate beds that phosphatic nodule beds are due to cold northerly currents. As many Crustacea are found to be contemporary with the lines of nodules in the Gault, the cold current theory may probably be correct, as in the North Atlantic at the present day, crustaceans are found to be most numerous in the cold water areas.*

In some of these lines of nodules, Mollusca of the same species obtain, which seems to point to the conclusion that as similar physical conditions recurred, so did like species; these nodules notably contain the carapaces of crustaceans.

It is an interesting subject to note that nearly all the genera representing the typical Lower Gault forms belong either to the Littoral, Laminarian, or Coralline zones, and that the lowest, Bed No. 1., represents the shallow or littoral sea, and the intervening beds up to No. VIII. in numerical order appear to represent the Laminarian and Coralline zones. As we examine the Upper Gault, *i.e.*, Beds No. IX., X., and XI., we find the clays become more marly until reaching Bed XI., when chalky conditions set in, and with them deep-sea forms make their appearance until we come upon the Chalk Marl, and finally the Chalk, which latter is generally accepted and admitted to be of oceanic origin. This tends to prove that the Gault was deposited in a sinking area, and that as we approach the Upper Gault we meet with evidences of the sea becoming deeper. The marly conditions of the Upper Gault likewise indicate deeper seas, and the appearance of *Terebratula* would probably point towards that also. Taking the recent *Terebratula vitrea* as an example for the habits of the *Terebratula biplicata*, it will be seen in Woodward's "Manual" that that species is found in the Mediterranean on *Nullipore* mud at a depth ranging from 90 to 250 fathoms. Then *Kingena lima* makes its appearance in Bed IX., and continuing upwards it occurs more numerously; this brachiopod may have enjoyed the same conditions as its contemporary, *Terebratula biplicata.* In Bed XI., in the greensand seam *Ammonites varians*, a Chalk Marl form, makes its first appearance. Upon looking through the list of Gault fossil Mollusca, we find the following have modern representatives, the particulars of the habitats of which I have extracted from Mr. Gwyn Jeffrey's "British Conchology."

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* See Works by Prof. Wyville Thomson and Dr. Carpenter.

BRACHIOPODA.

Terebratula is an Upper Gault form, being first met with in Bed VIII. In modern seas we find *Terebratula cranium*, Müller, is met with in 50 to 90 fathoms, on the north and east coasts of Shetland, but exceedingly rare in a living state. It is rather common on the Scandinavian coasts, and Dr. Wallich obtained dead specimens off the coast of Greenland at the several depths of 108 and 228 fathoms.

Mr. Gwyn Jeffreys states that he has taken *Terebratula caput-serpentis* at various depths, from 3 to 90 fathoms; and that the Rev. M. J. Berkeley found a living specimen of it attached to a rock at low-water mark, on a part of the Scotch coast, where the tide falls only a few feet. It will be seen from these remarks that the genus *Terebratula* has a very wide range in Recent seas, yet the conditions of the Lower Gault sea appear to have been unfavourable to it, since it is not found in that division.

LAMELLIBRANCHIATA.

Anomia.—The habitat of the modern representative of this genus, *Anomia ephippum*, Linné, Mr. Gwyn Jeffreys informs us, is from low-water to 80 fathoms; that it attaches itself to rocks, shells, &c. The same authority states that Danielssen dredged it in the Scandinavian seas from a depth of 180 fathoms. Woodward gives its range to 100 fathoms. In the Gault it is principally found in the Lower Gault in Beds I., II., V., VI., and XI., and upon rolled fossils in the nodule beds.

Ostrea is met with from low-water to 45 fathoms, and Woodward records it from low-water to deep seas.

Pecten is represented by several species which, according to Mr. Gwyn Jeffreys, range from low-water to 200 fathoms; at the depth of 150 fathoms *Pecten Islandicus* has been dredged in the Arctic seas. *Pecten pusio* lives in water at depths ranging from 5 to 85 fathoms.

Pinna.—The modern representative of this genus, *Pinna rudis*, Linné, Mr. Gwyn Jeffreys states, is found in muddy or sandy gravel from low-water mark to 80 fathoms. Woodward gives its range from low-water to 60 fathoms—this data very well accords with the position in which *Pinna tetragona* is met with in the Lower Gault, *i.e.*, Beds II., III., IV., V., and VI.

Cyprina.—The recent *Cyprina Islandica*, Linné, is met with in sand mixed with mud from low-water mark to 100 fathoms. In the Gault it is only found in Bed VIII.

Lima appears to range from 5 fathoms to 227—at which latter depth *L. subauriculata* was obtained by Wallich in the North Atlantic—*L. Loscombii*, G. B. Sowerby, was dredged by Capt. Beechey off the Mull of Galloway, in 145 fathoms. This latter species appears to approach nearest to *Lima parallela*, which in the Gault is met with in Beds II., VII., and IX.

Nucula.—This genus is found throughout the Gault more or less numerously, but more plentifully in the Lower Gault. Recent species of this genus are met with in sandy mud, and mud at depths varying from low-water to about 145 fathoms. Mr. Gwyn Jeffreys states that *Nucula sulcata* has been obtained by Forbes at depths varying from 45 to 145 fathoms. Capt. Beechey met with *Nucula nucleus* off the Mull of Galloway in 145 fathoms. These statistics likewise accord very well with what we find in the Gault.

Pectunculus.—The recent representative *P. glycymeris*, Linné, is met with from 7 to 90 fathoms, and the Gault forms are found in Beds II. and VI., but principally in Bed VI.

Arca and *Cucullæa.*—These two genera are collectively met with in the Gault in Beds II., III., VII., VIII., IX., X., XI. The Upper Gault appears to have been more suitable to their development, as they are found more plentifully and of larger size. *Cucullæa glabra* is of common occurrence in Bed VIII., and *Cucullæa carinata* obtains much larger in the Upper than in the Lower Gault. Mr. Gwyn Jeffreys records the various species of *Arca* as being met with in 10 to 200 fathoms. *Arca pectunculoides* has been dredged by Forbes in 200 fathoms in the Ægean sea. *Arca tetragona*, Poli, has been dredged on the Coast of Norway in 10 to 20 fathoms, and at Malin, on the coast of Sweden, in from 80 to 100 fathoms. This latter species appears more closely to resemble *Arca* (*Cucullæa*) *carinata* of the Gault, which is found in Beds II., IX., X., XI.

Trigonia.—The recent *Trigonia pectinata* is mentioned by Woodward as being very numerous in Sydney Harbour, which fact points to this genus being a shallow-sea, which is borne out by its position in Bed No. I. of the Lower Gault.

Astarte.—The recent *Astarte sulcata* has been met with off the Mull of Galloway, by Capt. Beechey, in 145 fathoms, and northwards at depths varying from 3 to 160 fathoms. Woodward states that it has been met with at depths of from 30 to 112 fathoms. This genus is of rare occurrence in the Gault, being only met with in Beds V., X., XI.

Tellina is met with in the modern seas from low-water to 78 fathoms; this is the depth given by Mr. Gwyn Jeffreys, at which *Tellina balaustina* was dredged off Shetland. This depth tallies very well with those at which this genus is met with in the Lower Gault, *i.e.*, Beds II., III., VI., VII. It is, however, a rare fossil.

Thracia, Mr. Gwyn Jeffreys informs us, is met with at from 4 to 100 fathoms, at which latter depth *T. convexa*, W. Wood, has been found off the coast of Sweden and Norway, but this is an extreme depth. *Thracia*, off the British coast, appears to have a range of from 4 to 60 fathoms. In the Gault it is found in Beds II. and VII.

Corbula.—*Corbula gibba*, Olivi, Mr. Gwyn Jeffreys tells us, usually frequents the Laminarian Zone in mud, sand, or gravel, and has been found in 72 fathoms water off Shetland. This genus is met with in the Gault in Beds II., III., VI., IX.; rarely, however, in the latter. It may be considered an essentially Lower Gault form, and its position in those beds accords with that of the recent genus in modern seas.

GASTEROPODA.

Rissonia incertata, D'Orb., is probably represented by *Rissoa*, which, for the most part, is a genus found at low-water up to and in the Coralline Zone, but principally in the Littoral and Laminarian Zones. *R. incertata* is by no means a common fossil, and is only met with in the Lower Gault in Beds II., IV., V., and VI., which position agrees with the depth at which the genus is dredged in modern seas.

Dentalium is common in the Coralline Zone, and is recorded by Woodward as being found in from 10 to 100 fathoms of water. It is numerous in the Lower Gault in Beds II., IV., V., and VIII., and has been found as a rolled fossil in Bed XI. of the Upper Gault.

Turritella.—*Turritella terebra*, Linné, the modern representative of the genus, is met with throughout our seas in sand and mud at from 3 to 100 fathoms. Woodward gives the range of *Turritella* at 15 to 100 fathoms. It occurs only in the Lower Gault in Beds III. and VII.

Scalaria is of the Coralline Zone, and is met with in Recent seas between 5 and 100 fathoms. Woodward puts it down as ranging from low-water to 80 fathoms. It is essentially a Lower Gault fossil, being met with in Beds II., IV., VI., and VIII., and as a rolled cast in pyrites in Bed XI. of the Upper Gault.

Natica.—*Natica Islandica*, Gruelin, is rare in the Coralline Zone, from 7 to 79 fathoms. This is possibly the ancestor of *Natica gaultina*, D'Orb. = *N. canaliculata*, Gould and Sowerby. *Natica Alderi* is found everywhere in sand from extreme low-water mark to the greatest depth within the line of soundings. This shows that the genus *Natica* has representatives at all known depths. It is met with throughout the Gault.

Apporrhais.—*Aporrhaïs pespelicani*, Linné, probably the modern representative of *A. Orbignyana* and *A. Parkinsoni*, is found in the Coralline Zone, and occasionally the deep-sea zone also, varying in depth from 5 to 100 fathoms. Fossils of this genus are met with in every bed in the Gault, but are rare in Beds X. and XI. of the Upper Gault.

Cerithium.—This genus is met with in Recent seas from the Littoral to the Coralline Zones, varying in depth from the shore line to 140 fathoms. According to Woodward it is limited from low-water to 40 fathoms. This is a Lower Gault form, never having been found above Bed VII.

Buccinum.—*Buccinum undatum* of the modern seas is now found in all parts of the British seas, from the shore to the greatest depths. The *Buccinum gaultinum* is only found in the Gault in Beds VII. and VIII.

Murex.—*Murex erinaceus*, Linné, is met with on stony ground, at low-water mark, and in the Laminarian and Coralline Zones. *Murex aciculatus*, of Lamarck, has a similar habitat. *Murex calcar*, Sow., appears to be most similar to *Murex erinaceus;* it has only been found in the nodule Bed VIII. of the Gault.

Fusus inhabits for the most part Laminarian and Coralline

Zones. The species most commonly found in the Gault, *i.e.*, *Fusus indecisus*, resembles very closely *F. muricatus*, which species is found in muddy sand in the Coralline Zone. This likewise accords with the position in which the genus *Fusus* is met with in the Lower Gault, *i.e.*, up to and in Bed VII.

Avellana.—Probably the modern representative of this Gault form is *Actæon*, which is met with in sandy bays at from low-water mark of spring tides to about 20 feet. Mr. Gwyn Jeffreys records it as having been found off Shetland in muddy sand at 80 to 90 fathoms. Woodward gives it from low-water to 60 fathoms. It is a Lower Gault fossil ranging from Bed III. to Bed VII., both inclusive.

Pleurotomaria.—This is not mentioned by Mr. Gwyn Jeffreys as being a British mollusc. Woodward records two species, one of which occurs in deep water in the West Indian seas. This would agree very well with the position in which it is found in the Upper Gault, *i.e.*, Beds IX. and X. It is, however, very rare as a recent shell.

TABLE I.

Shewing the Stratigraphical Range of Lower Gault Mollusca of the Higher Beds, with the habitat of their Recent representatives.

Genera of Mollusca occurring in the Lower Gault.	Beds of the Folkestone Gault in which each Genus occurs.	Range of Recent Species	
		After Gwyn Jeffreys.	After Woodward.
Pinna	II. III. IV. V. VI.	Low-water to 80 fms.	Low-water to 60 fms.
Pectunculus	II. VI.	7 fms. to 90 fms.	8 fms. to 60 fms.
Trigonia ...	I.	....	Shallow water.
Tellina	II. III. VI. VII.	Low-water to 78 fms.	Low-water to 50 fms.
Thracia ...	II. VII.	4 fms. to 60 fms.	4 fms. to 110 fms.
Corbula......	II. III. VI. IX.	4 „ 72 „	Low-water to 80 fms.
Rissoina ...	II. IV. V. VI.	4 „ 50 „ (Coralline Zone.)	....
Turritella ...	III. VII.	3 fms. to 100 fms.	15 fms. to 100 fms.
Scalaria ...	II IV. VI. VII. VIII. XI.	5 „ 100 „	Low-water to 80 fms.
Cerithium...	II. III. V. VI. VII.	Low-water to 140 fms.	Low-water to 40 fms
Buccinum...	VII. VIII.	All depths.	Low-water to 100 fms.
Murex	VIII. IX.	Low-water to 50 fms. (Coralline Zone.)	25 fms. to 60 fms. (rarely.)
Fusus	II. V. VI. VII.	Low-water to 50 fms. (Coralline Zone)	Low-water to 70 fms.
Actæon (Avellana)	III. IV. V. VI. VII.	Low-water to 90 fms.	Low-water to 60 fms.

With the exception of *Corbula*, *Scalaria*, and *Murex*, none of the above-named pass into the Upper Gault; of those few that do, only single specimens have been met with; therefore, we may consider the Lower Gault sea to have not exceeded 100 fathoms in depth, and it was probably very much shallower.

TABLE II.

Showing the range of Lower Gault genera found in the Lower beds, and which pass into the Higher, or those which lived in slightly deeper seas than the genera of Table I, and whose present representatives are found at greater depths —

Genera.	Beds of the Folkestone Gault in which each Genus occurs.	Range of Recent Species.	
		After Gwyn Jeffreys.	After Woodward.
Pecten	I. II. III. VIII. IX. XI.	Low-water to 200 fms.	Low-water to 200 fms.
Nucula	All throughout.	Ditto to 145 fms.	5 fms. to 100 ,,
Lima	II. VII. XI.	5 fms. to 227 ,,	
Arca	II. III. VII. VIII. X. XI.	Low-water to 230 ,,	10 fms. to 200 ,,
Astarte	V. X. XI.	3 fms. to 160 fms.	30 fms. to 112 ,,
Cardita	V VII. VIII. IX. XI.		Low-water to 100 ,,
Dentalium	II. IV. V. VIII. XI.	Low-water to 50 fms. (Coralline Zone.)	10 fms. to 100 ,,
Natica	II. IV. V. VI. VII. VIII. X. XI.	7 fms. to 79 fms.	Low-water to 90 ,,
Aporrhais	Throughout.	5 fms. to 100 fms.	Low-water to 100 ,,

The genus *Arca* becomes more frequent in the Upper Gault.

The Siphonostomata are confined to the Lower Gault, with the single exception of *Rostellaria*. The genera are *Pteroceras*, *Murex*, *Pyrula*, *Fusus*, and *Buccinum*.

The Holostomata are not so restricted, as a few examples of that division are met with throughout the deposit, such as *Aporrhais*, *Natica*, and *Dentalium*, but the last named is not so frequent in the top bed.

The following is a list of Holostomes:—*Natica*, *Aporrhais*, *Dentalium*, *Solarium* and *Scalaria*, met with in both Upper and Lower Gault. *Pleurotomaria* in the Upper Gault only. *Natica*, *Cerithium* *Turritella*, *Rissoina*, *Phasianella*, *Acmæa*, *Avellana* = *Actæon*, from the Lower Gault only. *Aporrhais*, although classed by some authors amongst the Holostomes, and said to be a herbiverous mollusc, is really carnivorous.

I inquired of Mr. Henry Woodward some time ago as to whether he could furnish me with any information as to the depth at which

Recent Crustacea, which might be considered to be descended from the fossil species, are found. His opinion was that in consequence of so very little being known as to the limit of depth at which Recent species are met with, he did not think we could take the Crustacea into account in the present paper.

I may, however, remark that they are found much more numerously in the beds of the Lower Gault than in the Upper. Some forms, such as *Necrocarcinus Bechei*, *Homolopsis Edwardsii*, *Hoploparia longimana*, *Palæocorystes Broderipii*, are restricted to the Lower Gault. *Palæocorystes Stokesii* is a species which is met with occasionally in the Upper Gault beds IX. and X. All these species appear to indicate that they did not inhabit very deep seas, which I think is substantiated by the fact of most of them occurring in or near to nodule beds. *Etyus Martini*, on the other hand, occurs very seldom in the Lower Gault, and those forms that are found are small, whereas in Bed X. in the Upper Gault, they are larger, and even numerous. *Diaulax Carteriana* is another genus, probably inhabiting deep water, found in Bed XI.

In conclusion, I think that these deductions tend to prove that the Lower Gault was a near-shore or muddy estuarine deposit, and that in course of time, as the sea-bed gradually sank, so did that sea naturally become deeper and deeper, as I have endeavoured to show by the slow disappearance of littoral and laminarian forms, and by the incoming of genera of deeper seas.

As the general results of this Paper are deduced from our present knowledge of the published range of certain genera, I do not overlook the fact that certain species of Gault Mollusca whose habitat cannot possibly be known, can, to a certain extent, modify observations drawn even from the comparison of apparently closely allied species with Recent ones whose habits are known.

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3. NOTE ON THE FLORA OF THE GAULT WITH DESCRIPTION OF A NEW PINE CONE.

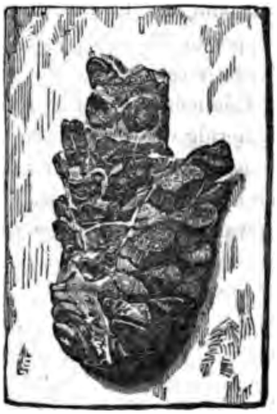
By WILLIAM CARRUTHERS, Esq., F.R.S., President of the Geologists' Association.

The Flora of the Gault as at present known consists of only a few species of coniferous fruits. In 1866, M. Coemans described the remains of an interesting flora from La Louviere, in Belgium, consisting of numerous coniferous cones, pieces of resin, fragments of coniferous wood, pieces of acicular and trigonal leaves all belonging to the genus *Pinus*, and the stem of a cycadean plant. All the coniferous fragments were referred to eight species of the genus *Pinus*, all of them new, and the cycadean plant was also an undescribed species. These fossils are all completely carbonised, and are preserved in plastic clays. They are considered to be of the same age as our Gault, from which, however, no plant remains of any kind had been obtained until within the last few years. For them we are indebted to Mr. J. S. Gardner, F.G.S. They have been described by me in the "Geological Magazine" for 1869 and 1871. Mr. F. G. H. Price, F.G.S., has placed in my hands another species, a cone belonging to the genus *Pinus*, and to that section which has the apophyses of the scales thickened and pyramidal. Including this cone we have now from the English Gault five species of plants all from the beds at Folkestone, and all belonging to the *Coniferæ*. It is obvious that these fragmentary remains found in Belgium and England are but the feeblest index of an extensive vegetation which is yet unknown to us, and, like the upland flora of the Carboniferous period, is probably entirely lost to us, except from these rare morsels that were floated down into the calm lakes or seas in which the fine mud of the Gault clays was deposited. We may speculate as to the associates of these coniferous plants in their native habitats, but we have no information as to their nature. They might be the precursors of the dicotyledonous vegetation which in the immediately succeeding periods flourished, but it is more probable that the water which brought down the cones and wood buried at La Louviere and Folkestone skirted in its progress some forests consisting entirely of coniferous plants, like those on the western regions of North America. The flora of the Gault is the last from which dicotyledonous plants are absent. Cryptogamous plants, Gymnosperms and Monocotyledons, constituted the whole of the previous vegetation of the globe as far as we yet know it from the remains that have been discovered. This state of things terminates with the Gault, for the superior Cretaceous beds, so closely allied with the Gault in their animal remains, introduce the higher organised vegetation characteristic of the newer beds and of our own day.

The fossils from Folkestone belong to two genera, *Pinus* and *Sequoia*. No traces of a cycad have been seen at Folkestone, and no fragment of a *Sequoia* has been observed at La Louviere. This may be considered as indicating, from the facts at present known to us, that the Belgian flora was the more ancient of the two, but I am not inclined on this evidence to separate them in time.

The three species of *Pinus*—viz., *P. hexagonus*, *P. gracilis*, and *P. Pricei*, belong to the *Pinea* group of the genus *Pinus*. The genus *Sequoia* of the present day is confined to two species, and these occur only on the Californian mountains on the western aspect of North America. Associated with them are a number of species of pine which belong to the section *Pinea*, and are indeed closely related to the forms which have been found fossil at Folkestone. We have then here an indication of the association of plants in geographical areas. This is the furthest limit in the history of vegetation on our globe to which we can carry the science of the geographical distribution of plants. In the association of dicotyledonous forms which appear in the latest Cretaceous and the Tertiary beds we have forms and often genera, now indigenous to the same provinces found together in the same deposits. But in the beds of Secondary age, older than the Gault, we have not yet discovered any association of forms leading up to the present distribution of the vegetable kingdom, while in the Palæozoic rocks there appears to be no data for geographical botany, as the species in a large number of cases were common to all regions of the globe.

I have much pleasure in associating with the new cone the name of our Treasurer, to whom I am indebted for it. It may be described as follows :—



PINITES PRICEI, *sp. nov.*

From the Gault at Folkestone: in the collection of F. G. H. Price, Esq. *Natural size.*

Pinites Pricei, sp. nov. Cone ovate-cylindrical, elongated, unequal-sided, slightly curved, one inch and five-eighths long, and seven-eighths broad ; scales on the inner surface flat, closely adpressed, on the outer surface with a thickened projecting pyramidal apex or apophyses, which was very much developed towards the base of the convex or outer half of the cone.

From the Gault of Folkestone: collection of F. G. H. Price, Esq., F.G.S.

The single specimen found is a partially opened cone, the large scales on the outer half having sprung out from the axis. As the scales of ripe, open cones always return to their original place when placed in water, one would have expected that this cone, after floating in the Gault seas, and being buried in the moist sand, would have had all its scales closely adpressed to the axis. It is probable that it was so far decayed that the fibres had lost their power of contraction through the absorption of moisture, and this is further shown by the apices of the scales having been worn by friction. None of the apophyses of the scales are perfect. The base of the cone is turned round to the inner side as in the unequal sided cones of our own day. This cone approaches among living species nearest to *Pinus contorta*, Douglas, and *P. Hudsonica*, Poir, both North American species, and found on the western mountains of the continent.

VISIT TO THE PALÆONTOLOGICAL COLLECTION OF THE MUSEUM OF PRACTICAL GEOLOGY.

April 3rd, 1875.

Director—Robert Etheridge, Esq., F.R.S., F.G.S., &c.

The collection of fossils illustrative of the Stratigraphical Geology of the British Islands, preserved in the Museum of Practical Geology, is displayed in cases and drawers in the two galleries of the Museum, the Lower being devoted to Palæozoic fossils, and the Upper to Mesozoic species, while a stratigraphical arrangement prevails throughout the whole collection.

Commencing with the Cambrian and Silurian fossils, Mr. Etheridge described the contents of the many cases of fossils, summarising the general characters of the fauna of each great group of British rocks from the lowest to the highest. For upwards of three hours the learned lecturer succeeded in obtaining the interested attention of the Members, as he led them from the Molluscan and Crustacean marvels of the Cambro-Silurian rocks to Devonian corals and fishes, and on to Carboniferous Brachiopoda and plant-remains, and then through the Upper Gallery with its palæontological treasures from Jurassic, Cretaceous, and Tertiary formations.

Subsequently the Director conducted the visitors to the Offices of the Palæontological Department, where he pointed out and explained the method of registering and cataloguing the enormous number of specimens which find their way to this great storehouse of the organic remains obtained by the Officers of the Geological Survey and others from the British Sedimentary Rocks.

EXCURSION TO RIDDLESDOWN AND CROYDON.

APRIL 17TH, 1875.

Directors—CALEB EVANS, Esq., F.G.S.; and J. LOGAN LOBLEY, Esq., F.G.S.

Leaving the train at Caterham Junction station, Members had but a few yards to walk to the fine section of the Upper Chalk at the western extremity of Riddlesdown. At the foot of the section, Mr. Lobley described generally the great Chalk formation as displayed in England, and pointed out the peculiarities of this section. Professor Morris, who was one of the party, then described the conditions which must have prevailed during the period of the deposition of the Chalk, and explained the relations of this formation to Cretaceous strata occurring in the Continental area. Gradually ascending the Down, while proceeding eastward, the Members attained an elevation which enabled them to obtain fine views of a portion of the Chalk country, with its finely swelling hills and riverless valleys, formed by the North Downs.

On reaching the mouth of the half-made tunnel of the abandoned Surrey and Sussex Railway, the ardent geologists immediately entered the excavation, and very assiduously examined the Chalk with its nodular and tabular flint here exposed. Mr. Caleb Evans, who has made the geology of this district his own, and who has, from his observations of the various Chalk sections of this neighbourhood, obtained sufficient evidence to enable him to divide the Chalk into palæontological zones, explained that the beds here exposed are the "Upper Kenley Beds," containing an assemblage of fossils markedly different from the fauna of the Purley Beds, higher in the series, and also from that of the immediately underlying Lower Kenley Beds. While *Inoceramus Cuivieri* is wanting in the Upper Kenley Beds, it is present in both the Purley Beds and the Lower Kenley Beds. *Holaster planus* and

Micraster cor-bovis occur in the Lower Kenley Beds, but are not found in the Upper, which appear to be characterised by the abundance of three of the best-known of Chalk species, *Micraster cor-anguinum*, *Ananchytes ovatus*, and *Spondylus spinosus*.

In his paper "On some Sections of Chalk between Croydon and Oxtead," Mr. Evans fully describes this and other sections exposed by the work for the formation of the railway; and the following list of species from the Upper Kenley Beds of this locality is given:—

PROTOZOA—
- Cephalites campanulatus, Smith.
- Brachiolites convolutus, Smith.

ECHINODERMATA—
- Ananchytes ovatus, Leske.
- Micraster cor-anguinum, Guielin.
- Cidaris vesiculosa, Goldf.

POLYZOA—
- Desmeopora semicylindrica, Ræm.
- Flustra.
- Hornera or Homæosolen.

BRACHIOPODA—
- Terebratula carnea, Sow.
- „ semiglobosa, Sow.
- Rhynchonella limbata, Schlo.
- „ Mantelliana, Sow.
- Crania Ignabergensis, Retz.

LAMELLIBRANCHIATA—
- Pecten quinquecostatus, Sow.
- Spondylus spinosus, Sow.

PISCES—
- Lamna.

The summit of the Down was then crossed, and following a pretty country lane the party struck the London and Brighton road at the picturesque grove called "Purley Oaks," near to which is the Chalk quarry in which was found a granite boulder, possibly deposited on the bed of the old Chalk sea by an iceberg from the ice-capped lands of the Cretaceous Epoch.

A rapid walk of a mile brought the Members to the outskirts of Croydon, where the Cretaceous rocks give place to the Tertiaries of the London Basin, the southern edge of which is here found. Near to the conspicuous tower of the Croydon Waterworks, a large excavation affords a good exposure of the junction of the Secondaries and Tertiaries, the Chalk with the overlying Thanet Sands being well exposed. This was the last section visited; and the party subsequently took train to London.

EXCURSION TO WATFORD.

May 1st, 1875.

Directors.—John Evans, Esq., F.R.S., President of the Geological and Watford Natural History Societies; Professor Morris, F.G.S.; and John Hopkinson, Esq. F.G.S., Hon. Sec. to the Watford Natural History Society.

In consequence of very unfavourable weather, the published programme of this excursion (which had been arranged in conjunction with the Watford Natural History Society) was abandoned, and a shorter route decided upon. After assembling at Holly Bank, the residence of Mr. John Hopkinson, the party, under that gentleman's guidance, crossed the country to the east of Watford, through which runs the Colne, in a Chalk valley with an alluvium bottom and slopes covered in places with gravel. On the further side of this valley, Professor Morris, illustrating his remarks by specimens taken from the spot, described the gravel as Drift re-arranged and re-distributed by fluviatile action, since not merely rolled portions of flints, but subangular pebbles of quartzite, sandstone, lydianstone, and fragments of other rocks, found only at considerable distances to the north and west, occur abundantly in the gravels of this and other valleys subsidiary to the great Thames Valley.

At Berry Wood a quarry section exposes the Chalk, with a very irregular surface underlying a capping of Drift. Mr. John Evans here interested the party by producing perfectly regular cones from Chalk flints, by simply striking the flint nodules sharply with a hammer, the impact of the hammer causing an increased density of the particles composing a cone the apex of which is the point of impact. This section is close to the river Colne, which at this place runs parallel with, and at a short distance from, the northern edge of the London Tertiary Basin. The Colne receives the rainfall of a considerable Eocene area, which, after percolating through the Drift and Lower Eocene sands, passes into the Chalk, and subsequently makes its way into the river, in some cases by springs in or close to its bed. In the beautiful grounds of "Otterspool" are several of these springs, giving forth never-failing streams of the clearest water. Six are at the bottom of the pool, and, together, yield no less than 300,000 gallons of water a day, forming a not inconsiderable affluent of the Colne. The party, through the kindness of Mr. S. T. Holland, the proprietor, visited this remarkable and picturesque pool, which, by a sounding, was found to be 16 feet deep; but so clear is the water, that the chalk bottom and even the springs in the deepest part could be distinctly seen.

In proposing a vote of thanks to the Directors, Mr. Lobley reminded the Members that that was the first occasion on which they had been led by a President of the Geological Society, and he trusted that this might be taken as evidence of the good will now existing between the two societies, each of which he hoped would continue to act vigorously in its own way; the Geological Society promoting the advancement, while the Geologists' Association furthered the diffusion, of geological knowledge.

On returning to Watford, the party were very hospitably entertained at Holly Bank by Mr. and Mrs. James Hopkinson previous to the departure for London by the evening train.

ORDINARY MEETING, May 7th, 1875.

J. Logan Lobley, Esq, F.G.S., F.R.G.S., Vice-President, in the Chair.

The following Donations were announced:—

"Abstracts of Proceedings of the Geological Society;" from that Society.

"Transactions of the Manchester Geological Society;" from that Society.

"Catalogue of Library of the Manchester Geological Society;" from that Society.

"Journal of the Society of Arts," April, 1875; from that Society.

"Annual Report of the East London Naturalists' Society, 1875;" from that Society.

"Watford Natural History Society, Laws and List of Members;" from that Society.

"Report of the Coal Commission, 1871;" from John A. Coombs, Esq., F.G.S.

The following were elected Members of the Association:—

Alfred F. Bret, Esq., M.D., Vice-Pres. Wat. Nat. His. Soc.; Matthew Hamilton Gray, Esq.; Albert J. Campbell, Esq.;

William Charles Lucy, Esq., F.G.S.; John Grant, Esq.; Colonel J. J. Gibb; Charles Salisbury, Esq., B.A.

The following Paper was read:—

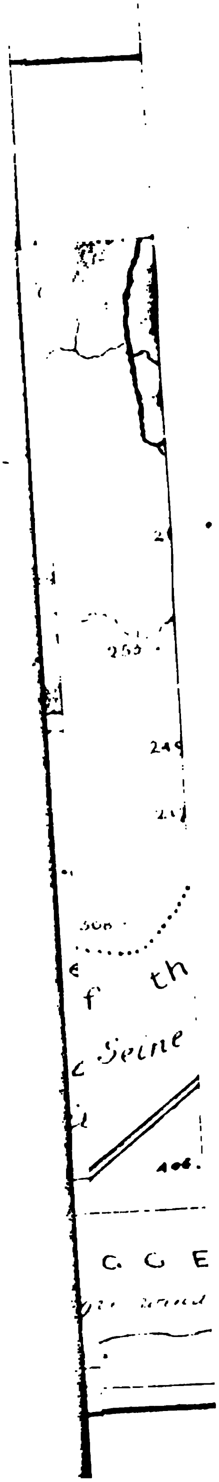
ON THE RELATIONSHIP BETWEEN THE SOMME RIVER AND THE SOMME VALLEY.

By JAMES PARKER, Esq., F.G.S., Hon. Fel. Ash. Soc.

The subject to which it is my purpose to draw attention in this Paper is the relationship of the Somme River to the valley which bears its name. Much has been written about the lithological character of the sand and gravel beds which appear on the slopes of this valley, and about the organic remains discovered in their midst; and much discussion has taken place as to the analogies existing between these beds, and those, to all appearance, deposited under similar circumstances elsewhere in France, as well as in our own country. But while these details have received so much attention, it seems to me that the far greater question, namely, how they came to be distributed in the positions in which we find them;—that is, why some are on the surface of the plateau, some in the hollows of the combes, some at the bottom of the valleys, while others are on the sloping sides of the same valleys—has not received the attention it deserves, or, rather, obtained the answer it requires before any conclusion can be drawn from the minor considerations of the lithological character, or the organic remains of the beds in question.

It has been *assumed* that the River Somme deposited them there, and that, therefore, no further questions need be asked on this head. But this assumption involves another, namely, that the river having deposited the gravels, cut a valley through them; or, rather (what this assumption practically comes to), that the River Somme made the valley which we now see. As a necessary consequence, too, it must be assumed that the tributary streams made the tributary valleys; and, in a word, that the present contours of the country are wholly due to river, or similar subaërial action.

It is my purpose, then, to examine the basis of these assumptions. I propose to ask, and to supply an answer to the question,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whether the River Somme can have, in any sense which may be applied to the words, *made the Somme Valley*. This lies at the root of the other questions which follow from it. If it cannot have made the valley, we have a strong *à priori* argument at least that it could not have deposited the gravels high up on the slopes, or cut through them afterwards.

And in treating the subject I propose to follow a line of argument, and to introduce considerations which have not, as far as I have observed, been treated by writers on the Somme Valley. I propose to ask your attention to the river as a whole, and the district as a whole, as this seems to me to be not only the natural order of proceeding, but also, as I venture to say, in this particular instance, the only right way of treating the subject.

The district to which I have to call attention is, speaking generally, the ancient province of Picardy, traversed by the River Somme from east to west. So much of it as belongs to the consideration of the question at issue is shown in the accompanying map. It will be seen that this map includes the whole of the water-shed of the Somme, together with that of some six or seven minor rivers, not tributaries of, but supplementary to, the Somme. In a word, the map shows the Basin of the Somme; and in order to bring this point prominently forward, a series of figures representing, in English feet, the heights of the more prominent elevations in each district are given on the map; on comparing them a general rise will be seen to exist from the centre towards both the northern edge and the southern edge. Also a rise (but not so great a one) towards the eastern end. The western side is open to the sea, and though high hills occur reaching to the water's edge, where in many places along the shore they appear as cliffs, still the average level, especially as the mouth of the Somme is reached, shows a considerable, though very gradual, fall from the eastern end.

The general idea would be represented by cutting a very shallow spoon across the middle, the upper end near the handle representing the ground whence the highest tributary stream of the Somme rises. Along the most depressed part the trunk-stream of the Somme flows, but it does not drain the whole. Two or three streams run *parallel* with it (but independently of it), on the north side, and two or three also on the south side.

On the north we have the Canche flowing out at Etaples, the

Authie flowing into the bay of that name. Then a small drainage stream scarcely to be reckoned. Then the Somme itself flowing past St. Valery, into a much larger bay than that of the Authie. South of this will be found the Bresle, reaching the sea at Tréport, the Yeres near to Criel and the Aulne and Bethune, having united themselves together, finally discharging themselves into the sea at Dieppe.

While the trunk streams flow more or less in a straight line towards the sea, at the head of most, and more especially at the head of the Somme, are a series of ramifying streams. In the latter case they join the trunk just above Amiens. In the case of the Authie just above Doullens, of the Bethune just above Neufchatel.

The tributaries which discharge their waters into the trunk streams, it will be observed, flow in a general sense at right angles to those streams. There is no tendency whatever to deflection in a westerly direction, such as one would suppose, had they owed their origin to any great flow of water from the east. When they bifurcate or ramify, they do so, on the whole, very evenly, in relation to their general downward course. I only briefly touch upon these points in this general description of the map, as they will necessarily be referred to again when I come to the argument.

Before, however, quitting the general description of the map, I should add that it may be relied upon for the accuracy of the general lines of the rivers and their branches, as it is a reduction of the French Ordnance Survey, to one fourth the scale. That is, each English inch on the reduced map represents as nearly as possible five miles.* The district here given is comprised in sheets No. 6, 7, and 8, 11, 12, and 13, 20, 21, and 22, in all nine sheets of that Survey. It will be observed that small portions at the N.W. and S.W. corners, beyond Montreuil and Dieppe are unavoidably omitted.

In order to bring more clearly into view the course of the rivers, I have omitted all the lines of roads, and communal boundaries, and of canals and railroads, which tend to confuse a map, when used for the purpose of studying the physical features only. Also the names of places are omitted (with the exception of very few, which are retained for the sake of speedy reference to the district, should any reader care to compare this map with others).

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* The French Ordnance Survey is $\frac{1}{80000}$ consequently the scale is not so large as the one-inch-to a-mile-scale of our own Ordnance Map. The map I have given is $\frac{1}{320000}$, which will be found to be one inch to about 5·05 miles.

It was impossible to follow, on the reduced scale, all the lines of hill-shading represented on the larger scale, and even in that case the numerous undulations are only very incompletely shown, or rather, only the chief contours are taken notice of. In the present map then, the brown hill-shading must be accepted as exhibiting only the more important contours, and then only approximately. While the shading tends to give a general idea of the country, I do not think it can in any way suggest any false notions. It remains to add that the red figures represent approximately* the heights of the points above the mean sea level, in English feet. They are selected from a much more extensive series, the *highest* in any one spot always being chosen. Consequently they do not by themselves afford data for computation of the *average* height of the hills in that part. Still, by taking the highest in any one district, and comparing it with those in another, a general, and not often inaccurate, idea can be gained of the relation which the heights of the hills bear to each other in the two districts. It would be beside my purpose in this Paper to give any detailed account of the geology of the country, but I must insert a few words to show the general uniform character of the district under consideration.

It may be roughly described as an undulating Chalk hollow, very slightly depressed, much broken into combes and valleys (and consequently presenting numerous hills), but with the main level of the synclinal axis, as already described, sloping very gently seaward, *i.e.*, to the west or north-west. Along this synclinal axis, the hills vary very much in height, as will be seen by noticing the figures along both sides of the Somme ; but on the whole, the fall is exceedingly slight. For instance, if a line be drawn from the top of the hills, immediately above the source of the Somme (and these represent the *average* height of the anticlinal, between the two great water sheds of the Somme and Oise), to the top of the hill just below St. Valery, overlooking the bay of the Somme, it will be found that the fall is only 250 feet in 75 miles, *i.e.*, at the rate of 3·3 feet per mile, or a gradient of 1 in 1,600.

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* The French heights are only given in metres, so that practically a margin of a foot-and-a-half or more is allowed either way. In reducing I have taken the *nearest* English feet to the metre given. Probably none of the heights are more than two feet out of the actual height, and the majority within a foot.

The greater part of this undulating Chalk territory, so far as I have had opportunity of observing, is covered by sands or loams, varying in thickness from one to six feet, in the higher portions, and not much more, as a rule, on the slopes of the valleys. In some cases, however, and especially in the latter position, the thickness of these deposits extends to 15 or 20 feet, and in one or two isolated instances, to still more.

Amidst these sands or loams, gravels are frequently interspersed: sometimes the pebbles are distributed very sparsely and irregularly amidst the sands; at other times they form *laminæ*, perhaps not more that an inch thick. In many cases they lie in long beds, but undulating and varying in thickness. Sometimes, also, but only under certain conditions, beneath the sands and loams is an underlying mass of gravel, several feet thick, the pebbles of which attain to a considerable size, and are mixed with large unbroken flints. It is in these thicker beds that most of the flint implements have been found.

The deposits of gravel, it should be added, consist in some places chiefly of broken angular flints, in others of rolled flints, and pebbles of various kinds. In most places the two are combined, but in varying proportions. The rule, indeed, is for the beds to vary considerably, oftentimes in the short distance which one section may present. At one time much sand is mixed with the gravels; at other times they are bedded in accumulations composed chiefly of loose chalk, and while rolled masses of chalk appear frequently with them, there are many instances in which laminæ of fine chalk grains occur alternating with the sands.

The point, however, on which I would insist in this general description is this. Although, perhaps, for the most part these gravel beds occur low down in the valleys, this is not an absolute rule, nor is there any consistent line to be drawn in relation either to the river, or an imaginary mean level, above or below which they occur. For instance, the renowned gravel deposits of the two pits belonging to the Frevilles are quite eighty feet above the Somme River, but just above them, within 500 yards, very similar beds are found at one hundred feet above the Somme level. This is by no means the highest level of the hills in the neighbourhood, as some near to this spot rise to 200 feet, and, in places, to even more, above the Somme at that part of its course. But then these hills are capped almost throughout by the same sandy loams, the very same loams (to all appearance) which cover, or are interpersed with the main gravel deposits at much lower levels.

So, then, these beds of sands and loams (often intermixed with gravels) are, practically speaking, of one general uniform character, spread over the hills and valleys without regard to levels. They are also spread over the *whole* district, without respect to the immediate presence of the Somme, or its tributaries. The neighbourhood of St. Valery presents the same general features as the neighbourhood of Amiens, and when once on the high ground near Amiens, it is difficult to discover any points of real lithological difference between it and the neighbourhood of St. Quentin.*

And now I would ask attention to one or two considerations arising fróm the circumstances which I have pointed out, in connection with the Geography and Geology of the district.

I pointed out especially the parallelism of the trunk streams of the six or seven rivers. They belong evidently to the same system of drainage. And, as I have also pointed out the uniform lithological character of the district, it follows that the River Somme must have had a common origin with the other streams. It cannot be separated from the river-system to which it belongs. In other words, no theory as regards the origin of the Somme can be held, unless it can be applied to that of the supplementary rivers. Nor can I see how the tributary streams can be excepted. For it is evident, when taking into account all the circumstances, the whole district has been divided out into combes and valleys by one common action, and on one uniform principle. The map shows this, but an examination of the district itself affords the more convincing evidence. Now, if the theory of the fresh-water excavation of the main valleys and of the tributary valleys be held, we must imagine that all the ridges and higher levels, from which, as the map shows, the higher tributary streams descend, were once bursting in all directions with springs of water, each possessing its own excavating force. Thus, and thus only, is it possible to conceive how, on the fresh-water theory of their origin, the results which the map shows were obtained. If it be not so, whence came the water? whence the erosive power?

But next, for the water from these springs to have had any force, it must have had, to begin with, a certain, if not a considerable fall, and one must therefore pre-suppose the main valley to be already in existence to receive it. It is the same whether we regard those falling direct into the trunk stream of the Somme, or those of any of the higher tributaries at the head of the river, the water from which must have had some lower level, presented by the Somme valley, into which to find its fall, and so give it the needed excavating force. But then it must be borne in mind (and I have to speak more fully of this presently) it is the water from the tributaries which go to make up the water of the River Somme. Without these it could have had no existence. Consequently, to say that the Somme excavated this very valley, which was necessary to its being called into existence, is simply absurd.

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* I perhaps should add that my recollection of the different pits in these two districts leads me to think that, on the whole, the gravel is more frequent and more abundant in the neighbourhood of Amiens than in that of St. Quentin.

But there is another difficulty, and, if possible, a still greater one, in supposing that water issued from springs on the tops of the ridges dividing the several trunk streams which mainly drain the district. To produce these springs you must have water-bearing strata on the plateau whence they descended, collecting and throwing out the water at given spots. This is not the case here, nor could it have ever been the case, since the last elevation of the district from the bed of the sea.

It is a Chalk district, and although the comparatively thin overlying deposits will in places collect and retain the rain-water (let it be, however, particularly noted that the origin of these very beds is attributed to the action of the Somme River !), it is, I shall presently show, when speaking of the main Somme Channel, very exceptionally that this occurs ; in other words, there are no *springs* at all which can be properly so called, or which could serve the purpose required. On the contrary, each combe or tributary valley (whether in the second, third, or fourth degree, like the valleys which in the upper part bifurcate and ramify to a great extent, as the map will shew) is, and was, entirely dependent on the rainfall on its own slopes, or on adjacent slopes communicating with it, for the water which now passes, or which ever passed along its valley bed, since it was exposed to the atmosphere. Consequently, this consideration shews that the tributary valleys must have been in existence before the presence of the very water, which, according to the erosive theory, is supposed to have formed them.

When, finally, both these arguments are taken into consideration, those who adopt the freshwater erosive theory will find themselves in this dilemma. They will see that the presence of the streams of the tributaries can, on their hypothesis, only be accounted for by supposing the previous existence of the main valleys to receive the water; but, on the other hand, the very water which they hold to have excavated the main valley could only have been obtained by supposing the pre-existence of the tributary valleys.

There is still one more consideration to which I have only briefly adverted in describing the map, and which I would recall again here. All the tributary streams flow into the trunk streams, in a general sense, at right angles—*i.e.*, north and south—although, as shewn by the map, the general drainage of the country is from east to west. Those who adopt the erosive origin of the valleys would admit, I suppose, *ex hypothesi*, a tolerably level plateau dipping towards the sea. On what principle, then, could the water in so regular a manner, as the map shows, have flowed in the two directions simultaneously; or, if not simultaneously, why should there have been a change?—and, if a change, which was the first direction of the drainage? Compared with the previous difficulties which I have pointed out, these may not be thought of so important a character, but still they may be well taken into account, when weighing the merits, or the fallacies of the erosive theory.

I have now completed the arguments which I propose to adduce from a consideration of the *district as a whole;* I proceed now to consider those which seem to me to be afforded by a consideration of the *river as a whole.*

The Somme from its head (which is some twelve miles N.E. of St. Quentin) to its mouth at St. Valery, measures in its course, as nearly as I can compute it, 124 English miles. Although, as is seen by the map, the lower part or trunk runs in a direct line, the upper part, which is scarcely distinguishable as to general outline from the tributaries, winds considerably amidst the Chalk hills, especially near Peronne. So that, while from its head to the mouth the direct line measures but 74 miles, the windings in this part add another 50 miles to its course.

It is nowhere what would be called a wide river, and in many places it is very shallow. It may be compared to the Thames; the part between Abbeville and Amiens being similar to the latter river between Teddington and Reading. A few miles above Amiens it is very like the Thames above Oxford.

Last year I took the opportunity of making an excursion up to its very head, and what I saw there impressed me forcibly with the difficulty of accounting for the phenomena seen along the line of the river, on any hypothesis of river denudation. At the back of the little village named "Font-Somme" (so called from its being the place of the source), and beneath some very gently sloping ground, appears what is best described as an ordinary village pond, some twenty or thirty feet across. The bank on the road side rises some six or eight feet above the bottom; on the field side about two or three feet. A few steps down the slope, and I found myself standing in the middle of the pond. I should add, the only vestige of water was a small puddle not more than an inch deep in its deepest part, and perhaps a couple of feet across at the widest measurement. So small was it that I did not notice it at all till I had been there some time. On the side beneath the road-bank there appeared to be some loose and fissured chalk, and from amongst this I learnt that the water came, when it came at all. My informants—two labouring men on the farm hard by—further told me that the pond had been in this state for three months. As this was in August, and the ground all around very dry, and as there was not much rain for some time afterwards I shall probably not be far wrong in saying that the source of the Somme was dry for four or five months last year (1874); and I understand that this was by no means an exceptional year in that respect.

An examination, however, of the neighbourhood immediately adjoining this dry pond, more than all led me to the conclusion that it was utterly impossible for the water from that source to have played any part in the conformation of the district. The hills immediately surrounding it are but gently rising tracts; their slightly undulating, or sometimes almost level summits, never exceeding 180, or at most 200 feet above the level of the pond,* and to reach them one has to walk a distance of a mile or two miles at the least. The little ditch-like channel (which at first I mistook for a path) from which the water flows when the pond is full shows the slight power possessed by the water to effect change; and as the fountain head could not obviously have been higher up or lower down, we have practically the gauge of the work it has done ever since any water has flowed from it.

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* The five chief hills ranging round the basin in which the source of the Somme lies are marked in the Survey as 94, 94, 97, 111, and 121 metres respectively, *i.e.*, =308 to 397 English feet above the mean level of the sea at Havre, which is, I reckon, 220 feet below the source of the Somme, at the "pond" of which I have been speaking. Beyond these hills there are one or two exceptional hills which rise above 400 feet (and one even to 571, about five miles off), but the average height is not above 400; and though this is debateable ground, both from the map and from the general aspect of the district, I came to the conclusion that if the rain which fell upon the beds of sand in the higher part found its way into any river at all, it was into the Oise, and not into the Somme.

If the force of the water supplied by the Somme is or was increased, it can or could have been so only by additions from the tributary streams lower down, and the result would be that we should have to suppose that some valleys were excavated in one way, and others, precisely similar, in a totally different way. Again: the area of supply must always have been as restricted as it is now, for when we connect the phenomena which are presented on the spot with the information which the map affords, we see that the drainage of the hills on the other side (and within a radius of less than two miles), falls away to the Oise,* and is by this river carried down to the Seine; or, if higher hills still are reached which lie further eastward, we find all the drainage passes down into the Meuse, and so into the German Ocean, so that we cannot look for a supply elsewhere than whence it is now derived.

It will be well here to speak of one or two of the circumstances which especially attend the Somme in its course, as they explain very clearly the machinery, so to speak, of the supply of the water which flows down the main channel. I have already pointed out that the proper source is dry for some four or five months in the year, and an examination of how this upper tributary of the main stream was gathering its water meanwhile, will go, I think, far to explain the whole system.

The little watercourse from the pond was also, as I have said, for some distance dry. After some time, however, it becomes wider, and the bottom, though it could scarcely be said to have much water in it, was covered at least with wet mud. Where I observed this first, I observed also that between the road which runs at the bottom of the slope of the valley and the ditch in question, there lay a considerable extent of marsh land. It could scarcely be called peat, though the soil approached very nearly to that substance both in colour and in texture. The openings in the ditches, cut for drainage purposes, and one or two larger cuttings possibly for the same purpose, showed, in many instances, something like water at the bottom, there being various degrees exhibited between absolute water and absolute mud.

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* A corner of the Oise just appears in the map. I have not complicated the map by putting in the streams which belong to the different watersheds, but I have thought it well to shew a portion of the Oise, and the source of the Scheldt.

After following the course for a mile or so, this ditch, which, theoretically, would be called the stream of the Somme, had distinctly water in it. Thence tracts of marsh land, at intervals varying some quarter of a mile or so in width, continue as far as St. Quentin; and here I noticed a very large expanse, a mile or more in extent, covered with water, but of no great depth, as the weeds and rushes showed themselves above the surface. No doubt this large expanse of water (now, to all appearance, a mere stagnant pool) receives *at times* some water from the stream of the Somme proper; that is, to put the matter more accurately, it receives some part of the rainfall of other valleys or combes than its own—many of them lying between St. Quentin and Fonsomme. But, for the most part, it is undoubtedly dependent on the rainfall of the few ravines and combes which open out into it, for its supply of water. One little tributary, too, appeared to be aiding it, and this, again, I found rose in an accumulation of peat-earth some two miles off, just beneath the village of Homblieres. The presence of these marshes and pools is no exceptional phenomenon; on the contrary, it may be almost described as constant, for as we follow the stream down to its very mouth, close to St. Valery, we shall find that for scarcely any distance its banks are free from the supplying influence of these accumulations—holding the water, as they do, like a sponge; and when we look at the smaller tributaries, we find them like the first I have named, rising from a sponge of this kind.

There are, in fact, very few springs properly so-called in the Somme district at all, as an examination of the large Ordnance Map will shew. I had, however, an opportunity of examining one which might be called so, from which water was still flowing, namely, the Fontaine de Cohu, near to Hangest. There was a steep hollow beneath the side of a road, which was carried along the base of a rapidly rising escarpment of Chalk, but I observed the chalk was much broken, and it was beneath the shattered portion that the water of the spring very gently oozed—sufficient, that is, to float a straw at the rate, as nearly as I could guess, of a mile an hour. But just below this spring, about a foot or so, and not a hundred yards off, was a current of water flowing briskly, having its rise and increase in a series of paludal accumulations extending more or less persistently the whole of the eight miles up the little valley, down which the little stream was still running so rapidly beneath the bright August sun, while all the fields near were dry and parched. At the very head the marsh ground in which it takes its rise is some hundred feet above the spring to which I have referred, and all along its course, and especially just above, and I may almost say behind, the escarpment from which the spring exudes, there are these accumulations. That some of the water of the stream (which, I may mention, turns two mills in its short course of eight miles) should be diverted some few hundred yards from its main line, and pass through some fissured chalk, is in nowise extraordinary; but it was the only example I found of a running spring during several days' exploration.

I have dwelt, however, on the circumstances attending the Fontaine de Cohu and the stream which flows past it, and which bears the name of the Ruisseau de St. Landon, because I believe the latter to be eminently typical of the lesser tributaries which supply the River Somme and neighbouring rivers with water.

I much expect that the spring at the head of the Somme is, after all, of a similar character. The Oise flows behind it, and, as far as I can judge, at a slightly higher level, for it is tapped by a canal which is tunnelled actually through the very hill beneath which the source of the Somme lies; and passing out within one hundred yards of the spot, the water in it is at least six feet above the highest point the water could have reached in the pond.

The River Oise, I noticed, was very low at the same time the spring was dry. Without more investigation than I had time to give, and without more favourable circumstances, I cannot say for certain that some of the marsh lands which usually give off a supply for the Oise behind the Fonsomme hills, may not at times give off by some subterranean fissure a supply of water which turns this dry hollow into a pond; but that this water possessed an excavating force, or was ever at a higher level, it is impossible to conceive.

This lesson, however, it seems to me is to be learnt from the phenomena which the "ruisseau" and the "fontaine" present to us, namely, how wholly the Somme is independent of any springs, in the usual acceptation of this term. On the contrary, it is wholly dependent on the rainfall of its own immediate valleys and ravines, held in suspension by the marshes and peat bogs—the "marais" and "tourbieres," as they are called—which have accumulated in their hollows.

The less extensive the accumulation of such water-holding (rather than water-bearing) media, the less the supply; and so the courses of the streams in the upper parts of the tributaries are narrow, but become more and more bountifully supplied as they pass by, or through, more of the sponge-like reservoirs, though no spring or brook aids the stream, and every ditch away from the marsh has been dry, it may be, for months previously.

But more than this, it is hard-indeed, to my mind, impossible—to conceive any other state of things in this district which would produce a supply of water. The pervious Chalk banks, covered in many places with such thin coatings of the sandy or loamy beds that the wonder is how they retain moisture sufficient to preserve the crops during the dry months, seem to oppose absolutely the theory that they could ever have given a supply of water in other ways than they do now. So that these tributaries throw in their quota of evidence in the same direction as that derived from the general aspect of the district—namely, first the valleys were called into existence, and then (and not till then) the formation of the streams and rivers which flow along them took place, and these, and these alone, made the Somme.

But the main stream of the Somme itself, in respect of its dependence upon the tourbieres, is the most remarkable of all. What we find in the tributaries is developed ten-fold in the main channel. Here the small reed-growing bogs and marshes are superseded by vast peat bogs of the extent of which only an actual inspection can give any idea.

Generally a mile wide, often more, they extend sometimes several miles in length without interruption; and here there will be seen also large pools, or even lakes, of water from whence the peat has been dug. I have found these lakes to be often 18 or 20 feet deep; and thus, besides the water-bearing power of the peat itself, we have a series of large reservoirs. So that it appears to me, were all the tributaries of the Somme cut off or diverted, the main stream would still flow gradually on for several months without any very perceptible change in the level.

A few moments' attention to the diagram of the neighbourhood of Amiens, which I have inserted at one corner of my map, will show the normal condition of the Somme Valley throughout almost all its lower course; the only difference being that the extent of the natural reservoirs, which I have described, is greater as we descend towards Abbeville, and less as we ascend to St. Quentin.

The edge of the tourbiere, at Longueau, is seen; and it will be observed that these numerous channels, which are cut in all directions, mainly, I conceive, for purposes of drainage and irrigation, hold, in the aggregate, an enormous quantity of water.

This accumulation of peat—this sponge-bed, as I may term it, of the Somme—practically provides the measure of the height of the stream. The Somme cannot rise higher, because water cannot rise higher, than its parent bed. And the Somme appears never to have risen higher than now but by a foot or so at most; at least, there are no traces on its banks, and it is inconceivable that under the conditions, if it had once been higher, none should have been preserved. Here and there, no doubt, there has been some slight change in the course. In one place the stream has been divided, in another it has been artificially turned, or its water diverted to assist the canal which flows the whole length of its course —by its side—or very nearly so. Slight changes of this kind, are, however, utterly insignificant, and cannot for one moment be of any account in the work which the Somme is supposed, by the "River-action Theory," to have performed.

I have no time to speak of the history of this peat formation; nor space to give the sections which I have made of some of the typical workings. All I wish to insist upon now is the important office it serves in the *collection*, storing, and regular supply of water to the river throughout the whole course.

Just as in the supply of water to the higher tributary streams, these beds of the main river have a part to play; so also as regards the main stream they have the same part, but, to a greater degree, to perform. Without the aid of the marais and the incipient tourbieres, the rainfall of the upper combes and valleys would pass off, or, at most, form, here and there, ponds and lakes, should any obstruction occur. At one time, however, they would be full to overflowing with water—at others, they would be perhaps dry from evaporation, and absence of a fresh supply, and that would be all. There would be no regular continual stream provided by the tributaries; no steadily flowing river in the main valley.

The *machinery* for producing the regular flow which we see the Somme to have, consists simply of these marshes and peat bogs; but, it must be borne in mind, they, and their supply, could have had nothing to do with the formation of the valleys, because the valleys must have existed before they themselves could be formed in their hollows.

A few words should here be added upon the very gentle fall of the river Somme itself. We have seen that in one of the tributaries I have named (and there are others similar) the slope is exceedingly rapid, *i.e.*, 100 feet in eight miles, or about 1 in 420 gradient. But in the main line of the Somme this is never the case. The river has to run 124 miles, and its highest starting point is only 220 feet above the level of the sea. This too must always have been its highest point, for water falling on the other side of the hill which bounds the source on the east, falls away to the Oise (as I have said), while that from the hills towards the north, falls away into the Scheldt or the Meuse, and so into the German Ocean.

To give some idea of this average fall of the river (which you will find is as closely as possible 1 in 3000), you have only to compare it with the Thames. The part below Oxford flows 1·5 foot per mile; that above Oxford is slightly more rapid (*i.e.*, 1·7 per mile), the Somme being 1·77 feet per mile. It will be seen what little erosive power either river has at this gradient; for if we may judge by the towns and monuments it passes by, it has made no material change during the Historical era. In a few cases the course of the Thames may have slightly altered, though this has been due chiefly to artificial interference, and not to any natural action.

But this is not all. This gradient cannot be taken as that of the Somme during the early part of its "eroding period," for there are hills continuing all along its course which had either been eroded previous to the coming into action of the river—and, if this is admitted, of course, *cadit quæstio*,—or else, the work of the river must have begun at the top of these hills. Now, down to St. Valery, and beyond it (for the hills reach a mile west of the harbour of St. Valery), the plateau varies from 300 to 100 feet, and at the very end it is 140 feet above the sea level. So that the river falling from 220 to 140 feet gives only a fall of 80 feet for its 124 miles. Some deductions in the latter case might be asked for on account of its course having been possibly more direct in some parts than it is now. Still, the fall, with an allowance for this, could not be more than one in 6,000—a gradient at which the power of water is so slight that it would, I believe, be found scarcely able to move the finest sand. How, then, could the thousands and millions of tons of chalk be eroded, and taken seawards, by a river under these conditions? It appears to me utterly impossible. Evidence, derived from what rivers may be seen to perform in India or America, falling from the Himalaya or Rocky Mountains, or what the Alpine rivulets, thrown down into narrow gorges, may effect, finds no analogy whatever in the gently undulating Chalk district of Picardy.

So much, then, for the evidence derived from the River Somme itself upon the question at issue. I trust I have succeeded in showing that it militates as much against the assumption of the river formation of the valleys, as does that derived from the general survey of the river district as a whole.

Before I conclude my Paper I must say a few words upon the supposed action of the river Somme in *depositing the sands* and gravels which are found in the valleys, and in their subsequent denudation. This question is a distinct one from that of which I have already treated, for it might be held that although the river may not have excavated the valley itself, it still may have filled a valley already formed, with sands and gravels, and subsequently excavated them, leaving only a few patches behind. And this view, it appears to me, is implied by some remarks of Sir Charles Lyell.

Nearly all the arguments which I have adduced as regards the supposed power of the Somme to excavate the original valley, apply with equal force against the theory of the excavation of the sandy and gravelly deposits which are supposed to have filled the valley up. But the question whether it could have deposited these sands and gravels before cutting through them, must be considered on other grounds; and on this point I wish to call attention to a few of the general and external features, reserving the details, and the consideration of the constituents of the gravel to some other opportunity.

I have already briefly referred to the fact that the beds in question are, speaking generally, spread equally over the high ground and the low ground. But there has been much misapprehension on this point in consequence of the general acceptance of the representations of these beds made by one or two French writers, coupled with the adoption of a nomenclature, based, I am convinced, upon isolated cases, and from a too narrow view of the questions which the phenomena present. The discussions as to the *diluvial* and *alluvial* beds, and the disputes about the lines of demarcation, have led those who have not studied the beds at different spots, to believe at least in a regular system of some sort, implying distinct and successive formations; and it has not been questioned at all how far all the difficulties arise from imagining succession, where only the laws of gravitation have acted on the materials deposited at one and the same time.

Practically, the result of their work, or rather the representation of so much of the opinion which appeared common to the chief writers, was cleverly embodied in a diagram which appeared in the late Sir Charles Lyell's popular work "The Antiquity of Man;" and I have given on the top corner of the map an accurate copy of the same, as it will, I think, tend to make what I have to say more clear.

The points which this diagram shows prominently are, first a level stratification of the beds unconformably with the sloping Chalk below; next, the apparent continuity of these beds across the valley, but cut through in a regular manner. These, when taken together, naturally give a most striking appearance of river action. Add to this the rapidly sloping Chalk banks, with their *terraces*, and the picture is complete—as the representation of an ancient bed of a river with the results of its work on each side.

This, you may remember, is given not as an isolated section, but as a typical section of the whole valley; and I should further add that the diagram professes to give the "hills reduced to one fourth their magnitude." The meaning must be that they are increased to four times their magnitude relatively to the horizontal scale, but I cannot forbear remarking (as a parenthesis) that in questions where the general appearance of a diagram has so great an influence on an argument, as in the case of a supposed bed of a river, it is a great mistake, for the saving a little space, to adopt any other than an equal, vertical, and horizontal scale.

Now, in criticising this section and while making every allowance for the exaggeration of the hills to four times their actual height, I am obliged first of all to say that I have not been able to find *any part* of the Somme Valley, where the gravels occur, having banks so steep. Further than this: the representation of the contours of the sides, instead of being typical, is so very different to anything which I have ever seen there, that I cannot resist the idea that the river hypothesis must have influenced in some degree —however unwittingly on his part—the artist who sketched it.

Instead of inventing an imaginary section across the valley, I have given one from actual survey, exhibiting the slopes as they really are. The line where the section is taken is marked upon the map of the neighbourhood of Amiens, and it is drawn to the same horizontal and vertical scale (viz., 640 feet to one inch). Although it is an actual section, it is at the same time a typical one of such parts of the valley as have extensive gravel-beds; but extensive gravel-beds, it must be remembered, only occur rarely.

On comparing the two sections you will, even making an excessive allowance for the exaggeration of Sir Charles Lyell's section, see that there is a great difference.

The fact is, the slope of the sides of what we call the Somme Valley is, as a rule, very gentle indeed. In some cases, it is true, a Chalk escarpment appears, but these are rare, comparatively, to the whole length. In most cases I may say that the slope is even more gentle than it is at Amiens, where this section is taken. Often, too, "combes" with a still more gentle decline pass down into the valley. A narrow one occurs near this section (*i.e.*, the valley of Blamont, across which the new boulevard is carried on an embankment,) considerably reducing the slope in that part. Besides these are the many large valleys opening out into the main valley: so that *on the average* the slope of the sides of the Somme Valley is even more gentle than in the section given.

And this sloping of the banks is an important element in the argument as to river action. The ideal section of Sir Charles Lyell at once suggests the work of a river. The actual section suggests something very different from what we see in fact, or understand in theory, to be a river bed.

The next point, however, on which the typical section appears to me to err is still more important. I refer to the imagined *continuity* of the beds across the valley.

I can say that instead of this being a typical feature, I have found no single instance of traces of gravels at equal levels on both sides of the valley, at the same spot, or indeed near the same spot. As I have said, it is only in isolated patches that the thick gravel beds occur at all, and when they are present on one side, they are usually absent altogether on the other. In the case of this section on the east of Amiens, where the gravel beds are developed perhaps as much as anywhere else in the Somme Valley, the opposite slope is, I believe, free from every vestige of gravel beds whatever. If these beds exist, there is little doubt but that the people would have discovered them, and worked them, but I have traversed the whole way between Amiens and Pont-Noyelle, and discovered no vestige. Only the same sandy covering, more or less impure by reason of its admixture with chalk, appears to cover the whole slope, as many road cuttings show. The slope, too, on this side, it will be observed, is at a slightly different angle to that on the south side; and this may be observed, in passing, as another point unfavourable to the hypothesis of river action upon homogeneous material. The so-called typical diagram, it will be observed, gives the sides equal, as well as an important bed of gravel continuous.

I need not notice at length the terraced character which is given to the banks in the section, and which, of course, goes far to help the hypothesis of the river action. Mr. Tylor, in a series of carefully measured sections, has shown that these terraces do not exist in any part which he has explored. I can add my testimony to the fact that no continuous horizontal terraces exist in any part I have explored also (and I may say I have traversed quite three-fourths of the course of the Somme), certainly not of the character as shown in the section.

Here again, however, one of the most important elements on which the theory of river action is based, although shown prominently in the "section," is wholly wanting in reality.

But the absence of all these features do not only *take away the evidence for* river action, which may have been adduced; they do more than this, for it is inconceivable that river action on so extensive a scale should not have left traces of the ordinary features consequent on that action. The absence of them, therefore, *goes far to disprove* that action.

Next it must be remembered that, although the gravel beds do not extend, so far as I know, over the highest points of the ridges which separate the six or seven great rivers which drain the district, the sandy earths and loams do. If the rivers deposited the gravel, what deposited these? Could the one or two tributaries nearest to the main axis so gush with water as to overflow the whole district, leaving only a few isolated hills, perhaps, raising their heads island-like above the water level? And what then, kept the vast expanse of water up? Imagine a large sheet of sixty or seventy miles broad, by above a hundred miles long, resting on an angle which will give in the latter distance 200 feet slope towards the sea. For if it covered the hills which are 200 feet above the level of the sea, it must have fallen in order to gain the sea level at the angle I have suggested. You must raise the level of the sea to keep it up. But if you raise the level of the sea above the hills, what becomes of the fresh water argument?

And, by the way, even at this elevation, there are in the district about St. Quentin plenty of the sands and loams, precisely similar to the rest, which will remain unaccounted for—for the hills here which are covered by them, rise to heights between 300 and 400 feet and even more.

I have an impression of having read in some geological works—whether English or French I do not remember—a theory which, if not stated directly, was at least implied or involved in the arguments adduced, that the *upper* loam covering was probably due to sea action, and that the whole district was consequently lowered to receive it. At the same time, the theory of a prior river action in depositing the said gravels and the *other* loams was persistently upheld. A moment's consideration will, however, show that the former admission is fatal to the latter theory. The very actions involved in the depression of so extensive a surface, and again raising it, if these were of a cataclysmic character, would create such disturbance that little of the sands and gravels so placed by the rivers would remain in their places, but be cast about, and find a resting place anywhere but where they were first deposited. If, on the other hand, the depression and elevation were slow, each part of the surface, sloping as it does seawards, would be brought into contact with the surface waves of the sea; and unless during the whole of the operation a constant calm was pre-supposed, the result would be still more subversive of all previous arrangement of the material.

And then when we look at the position of the gravels themselves, we find these difficulties. The fine gravel bed of the pits of the two

Frevilles, and of Tattegrain-Brulé (now exhausted) is only 75 or 80 feet above the Somme level at that spot; but near the same spot there are other similar gravels to be found, as high as 120 feet above the river level, *i.e.*, 185 feet above the level of the sea. Is it conceivable that any of the higher tributaries of the Somme, rising one hundred miles away, at an elevation only of 20 or 30 feet above this gravel bed, could have had force enough to bring down and deposit these gravels? Think of the many difficulties which suggest themselves. Think of the force required to remove so great a quantity so great a distance, bearing in mind, that it is effected after the valleys and hills, *ex hypothesi*, had already been scooped out—a force capable of moving the pebbles up hill and down dale (for the whole of the intervening land is surrounded by the tributary valleys). Think also of the expanse of the water at this elevation; in few cases less than two miles wide, in many above 20 miles. And if the main body of gravel was brought down only along the main excavated channel, what was the machinery which elevated it to its present height?

In a word, if the valley had previously been excavated, no water derived from any stream in these valleys could possibly have distributed the gravels in the position in which we find them. On the other hand, if the gravels were here before the rivers hollowed out the valleys, *cadit quæstio;* without the valleys there could have been no rivers to deposit the gravels.

And so I might go on presenting difficulty after difficulty, but there is no need. I contend that an attention to the contours of the district, and to their levels correlated with the levels at different points in the fall of the valley seawards, leaves no room to conceive that the gravels, either in their deposition or subsequent excavation, were due in any way to the rivers of the country.

So, then, I trust I have fulfilled the task which I undertook at the outset. (*a*) I have shown how a survey of the river system of the country with its arteries, on the slopes of the great dividing ridges of the plateau, separating the six or seven streams, proves it to have been impossible that water flowing over the gently sloping plateau, could have excavated either the main-valley hollows, or those which converge on each side towards them. (*b*) I have next shown how the nature of the river valley itself militated against this theory, by showing how it gathers its water, and how it always must have gathered its waters, ever since it was called into existence, unless some totally different action was at work, different not in *degree*, but in *kind* from what exists now. (*c*) And above and beyond that, I have shown how impossible it is, with the present physical character of the country then in existence, that the sands and gravels can in any way have owed their deposition or their excavation to any possible action of the river, with its present source and outfall with their existing relative levels.

The *assumption*, to which I have drawn attention, I think will be found to underly all theories respecting the history of these much disputed sands and gravels. And I trust, therefore, the Members of the Geologists' Association, will not think the time wasted in listening to or reading a somewhat argumentative, but at least an honest exposition of the grounds on which one of their associates conceives that the assumption can be shown to be untenable and consequently all theories based upon it, valueless.

EXCURSION TO CHARNWOOD FOREST, LEICESTERSHIRE.

WHIT MONDAY, MAY 17TH, 1875, AND TWO FOLLOWING DAYS.

Directors.—JAMES PLANT, Esq., F.G.S.; WILLIAM HARRISON, Esq. (Curator of Town Museum, Leicester); and WILLIAM MOLYNEUX, Esq., F.G.S.

(*Report by* WILFRID H. HUDLESTON, Esq., M.A., F.G.S.)

The party, under the guidance of Messrs. Plant and Harrison, met at Desford Station shortly after noon, on Whit-Monday, and proceeded in carriages to Lindridge Colliery. Mr. Mammatt, the engineer of the Company; Captain Marshall Hall, one of the directors; and Mr. Shore, the gentleman on whose property the sinking is made, were also present, and afforded every facility for the examination of the new works connected with the colliery. As this is a sinking through the Trias in a district not hitherto wrought for coal, the following section of the bore hole, furnished by the kindness of the above-named gentlemen, is given:—

Began April 10, 1874. First coal found, May 14.

			Keuper.	
Ft.	in.	Strata.	Ft.	in.
0	0	Red and Grey Marls	50	2
50	2	Smooth hard grey skerry	6	6
56	8	Red Marls (Gypsum)	86	10
90	0	*Strong Spring*		
143	6	Grey Sandstone	36	6
180	0	Red Marls (*Spring*)	78	0
258	0	Limestone	1	0
259	0	Red Marls	17	0
			Coal Measures.	
278	0	Sandstone (plants)	9	0
287	0	Coal	4	0
		Parting	2	0
291	0	Coal	8	6
301	6	Grey Rock	27	10
329	4	Coal	4	0
334	0	Grey Bind	35	0
333	4	Limestone	0	8
360	0	Coal	3	0
372	0	Limestone, with fossils	1	0
		Grey Rock.		

The position of Lindridge is four miles south-west of the last continuous boss of the Charnwood ridge, at Groby. Two borings were made, about one mile apart. At the most easterly the "hard bind" of the Coal Measures was found dipping at a very high angle, and no further bòring continued there. One mile to the westward, where the present sinking was being made, the beds are flatter, being further from the Charnwood axis, which is continued under the Trias, several miles south of Groby, as indicated by small bosses of fine-grained crystalline rock appearing on the surface.

The following remarks made by Mr. Plant serve to explain the physiography and general geology of the district:—"Where we now stand is about 18 miles from the river Trent, the north boundary of the district, and about three miles from Charnwood Forest, which bounds it on the east side. On the west flank is the Hartshill range, a little less elevated than the Charnwood, the average height of the latter being about 600 feet, the former 400 feet, with an indefinite boundary towards the south, embracing an area of about 200 square miles, which comprises the Leicestershire coal-fields. To the north of us the Coal Measures come out at the surface. On the east the Charnwood Forest or Coleorton field extends, while the Moira stretches on the western side. The southern portion lies under the New Red formation, being covered by the uppermost beds of the New Red Sandstone. Forty years ago a practical miner and distinguished railway engineer predicted that there was no coal to be found south of this point in this direction. The Bagworth coal-fields are the answer to that erroneous opinion. There, coal is found at a depth of 320ft. below the Red-marl, where it must be noticed there is no Bunter or Permian strata. With reference to this Lindridge Colliery, I must confess I was afraid that the ridge of igneous rocks extending from Groby due south, and which might be reached near Lindridge, would be struck, and so coal would not be accessible. However, that fear has fortunately proved to be groundless, as the evidences around us testify. You must not suppose that this is the most southerly extension of the coal-field, as it is found six miles further south. Before concluding, I might just remark that you are now standing upon the Water-stones commonly called the Lower Keuper Sandstone, upon rippled-marked beds indicating old sea beaches of the formation. Here it is possible for you to find the footprints, jaws, and feet of the *Labyrinthodon*."

The party then adjourned to Lindridge Hall, where they were most hospitably entertained by Mr. Shore, who had prepared a really sumptuous luncheon, the discussion of which somewhat shortened the day's programme. This act of hospitality was duly acknowledged, on the part of the Association, by Mr. Hudleston and Mr. Plant, the latter taking the opportunity of showing the important advantages which Mr. Shore would confer on the town of Leicester with its 110,000 inhabitants by the discovery of workable coal within such a moderate distance.

An adjournment now took place to the grounds, where cores of rock, obtained in the boring, were exhibited. Here Mr. Molyneux, gave a brief account of the Coal Measures of the district.

It was already rather late in the afternoon before the party arrived at the syenite quarries of Groby, the southern termination of the Charnwood range. Immense quantities of paving stones are quarried from these rocks, which are true syenites, *i.e.*, binary compounds of orthoclase and hornblende. There is, of course, considerable variety in the different beds, as well as change in the system of jointing. Besides the ordinary syenite made up of good-sized crystals, a handsome rock, there are beds of a very fine-grained variety which seem to occur athwart the general system of bedding. In the second pit the jointing is more vertical, though the character of the rock is much the same. The Rev. T. G. Bonney writes—" I have examined microscopically the Garenden and Groby syenites — true syenites, though much altered—'messed,' I might say, subsequently." The rock generally appears to consist of a flesh-coloured felspar, with good cleavage, and of a certain amount of hornblende, which, where undecomposed, is nearly black. The hornblendic element seems, however, to have undergone a considerable amount of alteration—decomposition, one might rather say—the result being the production of a green-coloured mineral, which has largely stained the felspar. Pink and green, therefore, are the predominating colours, justifying to a certain extent the name of "syenitic greenstone," which has been applied to this rock. The joint faces are often lined with a green mineral matter, which sometimes resembles epidote, and sometimes is of a serpentinous character. All these may be looked upon as altered products from the original hornblende, produced in the 'wet way,' and have nothing to do with the original formation of the rock, which has all the character of an igneous one.

One very interesting feature here is the Upper Keuper Sandstone, which may be seen to rest upon the upturned edges of the old rock, in positions suggesting a sort of quaquaversal dip away from a rocky islet in the Triassic Sea. Between the syenite and the Triassic sandstones and marls there is a conglomerate of pebbles and boulders, chiefly made up from the neighbouring rock, in a pasty matrix, somewhat analogous to the Dolomitic-conglomerate of the Mendips.

A short drive brought the party to Newtown Linford, situated in the anticlinal valley of the Charnwood range, now wholly filled with beds of Keuper age, where all dismounted and entered Bradgate Park on foot. Here an immediate change in the character of the landscape proclaimed the presence of that great body of syenite, which constitutes the southern termination of the eastern wing of the Charnwood range, just as the Groby syenites are the southern termination of the western wing. Ragged, splintery edges of rock start out of the steep hill-side, which is dotted with oaks short in stature and most picturesquely gnarled, a bit of Cambria or Caledonia in the midst of the rich Midland of England. The ruins of Bradgate Hall are close by. The place was set on fire, tradition says, by a former countess, who found the country dull, and wished to return to more animated scenes. Further on the slaty beds of the Charnwood series occupy the surface. Near "Old John Hill," which is the highest point of Bradgate Park, we find the cleavage planes dipping north, whilst the beds dip to the south, at an angle of 60°. In some places there is a remarkable ribboned appearance, due to variegated colouring in the bedding planes. Hereabouts the cleavage is often very imperfect and coarse. It was noticed by several members of the party that these slates have a very "ashy" appearance, not unlike those of the Volcanic rocks of Cumberland, now so well known through the labours of Mr. Clifton Ward, of the Geological Survey. The view from Old John Hill is magnificent; and Mr. Plant failed not to enlarge upon the physiography of the district, dwelling especially upon the configuration of the country as it had been left by Glacial erosion.

The party now proceeded to the great wood of Swithland, where there are several slate quarries. The one visited is a great excavation, 150ft. deep. The general dips here are about 45° in an easterly direction. It was already too dark, however, for much accurate observation. Two members of the party volunteered to descend the chasm, and were, unfortunately, left behind; a large portion of the remainder missed their way in the big wood, and, after wandering about for some time ultimately regained the carriages, and proceeded in the direction of Mount-sorrel, and so to Leicester.

TUESDAY, MAY 18TH.—The party proceeded by the Leicester and Burton Branch Railway to Bardon Hill Station. The first thing inspected was an old road-stone quarry in the slate, now converted into ornamental grounds. This is at the foot of Bardon Hill. The cleavage of the slates is very imperfect, but the bedding is distinct, with a strong dip to the S.W., *i.e.*, away from the great boss of Bardon Hill. Amongst other objects of interest in this section is a band of old conglomerates, containing a number of rounded pebbles. A specimen of one of these pebbles consists almost entirely of pink orthoclase and vitreous quartz—no mica or hornblende. This was *in situ*, but amongst a group of stones forming a "rockery" were some specimens of the so-called slate from near the top of Bardon Hill, which was a typical volcanic breccia, or, rather, an "ash," with large, included fragments precisely similar to examples from the Volcanic rocks of Cumberland. Unfortunately, no actual junction between these slates and the Bardon Hill Stone was observed. This stone is quarried exclusively for road-metal, since it cannot be broken into cubes, as are the syenites. On the Survey map it is indicated as a greenstone. The Rev. T. G. Bonney writes—"The greenstone of Bardon Hill is a felstone; it has orthoclase and much quartz in it. I rather think it is the stump of a plug or cone, for there is much agglomerate on one side of the hill." It is less distinctly crystalline than the syenites of Groby, or the syenitic granite of Mount-sorrel. The prevailing green colour is probably due to the subsequent decomposition of small quantities of hornblende, or other magnesia-lime silicate, the resulting green hydrous silicate being more or less diffused throughout the whole rock. This description is not, however, applicable to the whole mass, as there are many varieties; some in the vicinity of quartz veins presenting mineralogical features of much interest. The green colour, in some instances, also may be due to the presence of a mineral of the epidote class. A system of planes, dividing the rock into large slabs, dips inwards in a direction of E.N.E.; and intercalated between these planes in one place, near the entrance of the quarry, is a parallel mass of rotten foliated rock associated with quartz. This has been called mica-schist. It is rather rich in magnesia, with a considerable amount of ferrous oxide, but is poor in lime, silica and alumina being, of course, the principal ingredients; and it may be viewed, perhaps, as a sort of talco-micaceous schist.

Not the least interesting part of the morning's work was an examination of the self-acting machine for breaking stones, invented by Mr. Everard's son. The working of this was most fully explained by Mr. Everard, jun., who had very kindly (though the men were holiday-making) had the mill set at work for the benefit of his visitors. The stone is delivered from the face of the quarry into small waggons which run down the incline by the force of gravitation, and discharge themselves into the breakers; the empty waggons returning on another set of rails, forming one continual circle of operations for the delivery of the stone. The stone falling into the hoppers, is delivered into self-acting crackers, worked by a powerful steam-engine and by the aid of very ingeniously-contrived self-acting machinery, and the broken stone is sorted into three or four qualities into the railway trucks ready for delivery. The whole of the mill and machinery reflects the highest credit on the inventor; and we believe, as far as stone-breaking is concerned, it is unique.

The ascent of Bardon Hill, the highest point in the forest—854 feet above sea-level—had formed part of the programme. Mr. Herrick, of Beaumanoir, had been good enough to send his steward to act as guide to the party; but the weather was so unpropitious that the ascent had to be abandoned, together with the intended walk to see the "porphyrite" rocks of Greenhill. Of these Mr. Bonney writes—"The porphyrite rocks are not igneous, only extremely metamorphosed, and, so far as I know, are not conspicuous for plagioclase felspar; therefore, they should not be called porphyrites."

It is somewhat remarkable that both the period of upheaval, and the period of formation, of these Charnwood rocks, should be still the subject of much dispute, notwithstanding the considerable amount of attention which they have received from geologists. Respecting the period of upheaval, it may be gathered, from the statements of Mr. Plant and Mr. Molyneux, that both these gentlemen believe it to have been *post*-Carboniferous; Mr. Molyneux especially expressing himself to the effect that it was the prolongation of the Penine axis which had "broken the back of the coal." It had been Mr. Plant's intention to have given a fuller exposition of his views on this point from the summit of Bardon Hill. The adjournment of this section of the excursion party from the quarry to Mr. Everard's luncheon table, however, prevented him from fully developing his views on this and other points. Writing, subsequently, he says, "The age of the anticlinal has been a matter of dispute ever since geology was a science; my opinion, after nearly thirty years' study of it, is that it is *post*-Carboniferous.

Professor Hull says it is *pre*-Carboniferous, and that the Mountain Limestone of Grace-dieu 'lies unconformably on the up-turned edges of these Cambrian rocks.' The question is one of immense significance, viz., the existence, or non-existence, of a coal-field to the east and south-east of Charnwood." On the faith of this more sanguine view of the question a boring through the Keuper marls is being executed close to the town of Leicester,[*] at a spot not far from the well-known Rhætic section, which has been worked with such success by Mr Harrison of the Leicester Museum. Should coal be found there, the views of Professor Hull would scarcely seem to be sustained in that quarter. That geologist was of opinion that an old land-surface[†] existed during the Carboniferous period extending quite across England, from Wales to the Wash, and that the Charnwood hills are portions of that old land-surface, in a hollow or bay of which what are now the Leicestershire Coal Measures were deposited.[‡] It is quite possible that this may have been so, and yet that this old land-surface felt the effect of those elevatory forces, which, acting on N. and S. or Penine lines, have tilted the Coal Measures in post-Permian times. This would serve to explain why local geologists view the Charnwood anticlinal as post-Carboniferous; but that by no means takes away the possibility of its having been an old land-surface during Carboniferous times, and that the Leicestershire coal-field is an original basin of deposit, terminated at its eastern margin by pre-existing land-surfaces. The period and mode of formation of the Charnwood rocks, is equally a subject of dispute, though, as the issue has no economic importance, these are matters of purely geological interest. By the Survey, they are called Cambrian, because, as Professor Ramsay told Mr. Plant, there were no sedimentary deposits of older date then known. Since then, Mr Plant has suggested in the "Geological Magazine," that, from Murchison's own data, they ought to be called Laurentian. Hence, it appears, there is a general idea of their being very old indeed; and, as they are only found in company with very much more recent rocks, we have nothing to prove the contrary. Lithologically, the resemblance of some of the slates and agglomerates to the volcanic rocks of Cumberland, has been already noted; thus they may ultimately turn out to be Silurians of the same age as these beds. The mode of formation, is also a subject of much dispute; and Professor Ansted has taken extremely metamorphic views. He appears to consider that one great deposit of marls, clays, and sand, was, in very early times, upon an axis of depression then existing over Western Europe, lowered within the scope of metamorphic action, and then brought up again, on an axis of elevation, itself one of the most ancient in Europe. It is very difficult to avoid believing that the syenites of Groby and other places, are true igneous rocks, although they may have undergone a considerable amount of alteration due to chemical changes, acting through long periods of time; but this is very different from what is usually understood by metamorphism.

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[*] Mr. Harrison, writing Nov. 12th, 1875, says:—"The boring has, it is stated in last week's local papers, reached the New Red Sandstone; they are down nearly 700ft., through red marl and clay, and have now reached a bed of sandstone. If this is the Upper Keuper Sandstone, it is overlaid by a much greater thickness of marl than farther west, where some 200ft. only are found above it."

[†] "Coal fields of Great Britain," 3rd Ed., p. 464.

[‡] "The known coal areas of England seem to have been deposited to the north and south of a tract of Carboniferous land surface, to which I have several times alluded under the term of the 'Barrier.' This tract of land appears to have extended from Wales, Shropshire, and Herefordshire, towards the east, along the southern margin of the South Staffordshire coal-field. The prolongation of this land surface may again be recognized in the Cambrian rocks of Charnwood Forest; and between this part of its range, and that of South Staffordshire and Worcestershire, there was probably a deep bay, stretching in a southerly direction, which was filled in by the prolongation of the Leicestershire coal field." "Memoirs of the Geological Survey, Triassic and Permian Rocks of the Midland Counties," by Ed. Hull, M.A., F.R.S., page 109.

After enjoying Mr Everard's hospitality, this section of the party had a rainy walk to Coalville, where they joined the rest, and all proceeded by rail to Gresley, a station on the Moira coal-field*

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* The following notes on the Leicestershire Coal-field are obtained principally from "Hull's Coal-fields of Great Britain," page 225 *et seq*. Superficially, its western, northern, and southern edges are bordered by the Trias, and on the N.E., by the ancient rocks of Charnwood Forest. The Coal Measures underlie the Trias (here consisting chiefly of Keuper Marls) to a large and unknown distance towards the south and west. The coal-field is physically divisible into three districts—that of Moira, on the west; Ashby-de-la-Zouch in the centre; and Coleorton on the east. The first and last only contain workable coals. The coal series of these two districts cannot be identified with each other, though they are probably synchronous. The "main coal" of Moira is from 12ft. to 14ft. thick; that of Coleorton from 6ft. to 8ft. The new colliery at Lindridge, would, of course, belong to the Coleorton field in its southerly extension beneath the Keuper.

Coal Seams of the Leicestershire Coal Fields (page 227).

Moira district—(West).	ft.	in
Ell Coal	3	8
Dicky Gobbler	3	6
Block Coal	3	6
Little, or Four-feet	4	6
Cannel	3	6
Main { Over Seam Nether Seam	12	0
Toad	3	6
Little Woodfield	2	6
Woodfield	5	6
Stockings	9	0
Eureka	4	6
Strata below this unproved		

Coleorton district—(East).	ft.	in.
Stone Smut	4	9
Swannington	3	7
Slate Coal	4	8
Coal	2	10
Coal	3	7
Main Coal	6	0
Upper Lount	3	9
Second Lount	3	0
Middle Lount	4	6
Nether Lount	4	6
Heath End Coal and Cannel	10	0
Lower Coal measures.		

some distance to the west of Ashby-de-la-Zouch. From Gresley, the party walked down the line about a mile towards the Coton Park and Linton Colliery—passing, on the way, a section of the lower portion of the Pebble-beds of the Bunter.

This is an instance of a shaft being sunk through beds of Triassic age, in order to reach the rich seams of the Carboniferous Series of Moira, which are here at a very moderate distance from the surface. The main seam is upwards of 14 feet thick, and is mostly good coal, with no gas. Whilst waiting the arrival of Mr. Molyneux, some of the party amused themselves by inspecting the "gobfires," which had converted the rubbish heap of the pit into a little volcano. Shovel fulls of sulphur might have been taken away from here before the rain. Many "needles" and "flowers" of sulphur were still to be had. There was also a considerable quantity of ferrous sulphate, likewise the result of the oxidation of pyrites, which is plentiful in the smutty clod; crystals of salt are not uncommon.

After partaking of the hospitality of the Company, of which Mr. Molyneux is one of the directors, the party descended into the workings, which are remarkably clean and dry. As there is no gas, each Member was provided with a candle, and the effect of such an illumination on the shining walls and roofs of "black diamond" was most striking. These galleries—lofty, indeed, for a coal mine—are all hewn out of the coal, the workings having a face of 10 feet. The roof contains numerous compressed plant remains, mostly *Sigillaria.*

On returning to the surface, Mr. Molyneux addressed the party on the geology of the district; after which the train was taken for Leicester. In the evening many of the Members availed themselves of the opportunity of inspecting the Leicester Museum, under the direction of Mr. Harrison, the Curator.

The following is taken from a local newspaper:—

Wednesday.—To-day Barrow lime-beds were set down for a visit. The train from Leicester was taken, which soon brought the party to the Lias beds. Here the various operations of removing, lifting, burning, and grinding the limestone were witnessed. This was succeeded by a search for geological rarities. One or two of such were found. Ammonite casts and *Pectens* were very abundant. From Barrow, Mount-sorrel was soon reached, where, under the guidance of Mr. Edmunds, a minute inspection of the Mount-sorrel Granite Company's extensive operations was carried out. Luncheon was here very generously provided. The company then made a tour of inspection of the hill, where the remarkable Glacial action, the most perfect of its kind in England, was pointed out. A brisk discussion took place as to the origin of the Drift found at the side of the hill. The fact of Liassic and Oolitic fossils being common in it, is conclusive against its being a true moraine, though it partakes more or less of a moraine character. A trap dyke on the flank of the hill, about six inches in width, and extending for several hundred yards, and composed of pure felsite, was next noticed. The Members carried off specimens of this intrusive igneous rock. Simpson's Quarry was then visited. This place has a historic interest, it being that visited by Professor Airy (Astronomer Royal), the late Professor Whewell, and Professor Sedgwick. These found a trap dyke of greenstone in 1834, but as the quarry has been worked, that has probably become obliterated, no trace of it being now visible. The gneissic rocks were next visited, after which the company returned to Sileby Station, whence most of them proceeded to London. Thanks are due both to Messrs. Ellis and Son and the Mount-sorrel Granite Company, for their kindness in permitting so thorough an inspection of their works. The arrangements for the various excursions were, on the whole, well carried out; and the Members doubtless returned to their various homes with the pleasant thought that they had derived both pleasure and profit from their visit to ancient Charnwood.

ORDINARY MEETING, JUNE 4TH, 1875.

WILLIAM CARRUTHERS, Esq., F.R.S., President, in the Chair.

The following Donations were announced:—

"Quarterly Journal of the Geological Society," Vol xxxi., Part 2; from that Society.

"Abstract of Proceedings of the Geological Society;" from that Society.

"Journal of the Society of Arts," May, 1875; from that Society.

"Journal of the Quekett Microscopical Club;" from that Club.

"Proceedings of the South Wales Institute of Engineers," Vol. ix., Parts 1 and 2; from that Institute.

"Les Reptiles du Terrain Crétacé du N.E. du bassin de Paris," par M. Chas. Barrois; from the Author.

L'Aachénien et la limite entre le Jurassique et le Crétacé dans l'Aisne et les Ardennes."

"Ondulations de la Craie dans le Sud de l'Angleterre," par M. Chas. Barrois; from the Author.

"Om Skuringsmærker Glacialformationen Terrasser og Strandlinier," by Prof. Theodor Kjerulf.

"Jættegryder og Gamle Strandlinier i fast Klippe;" by S. A. Sexe.

The following were elected Members of the Association:—

Thomas Belt, Esq., F.G.S.; John Dallas, Esq.; Musgrave Heaphy, Esq.; Arthur Buck Kitchener, Esq.; Major John W. Woodall, M.A., F.G.S.

The following Papers were read:—

1.—ON THE FLORA OF THE LONDON CLAY OF SHEPPEY.

By WILLIAM CARRUTHERS, Esq., F.R.S., President of the Geologists' Association.

The Flora at present in existence on the earth dates, to a certain extent, from Upper Cretaceous times, as far as our present information goes; and on the Continent, remains of dicotyledonous plants occur in the Lower Eocene of which the London Clay of Sheppey is an important member. Up to this time—that is to say, previous to the commencement of the Tertiary period—the Flora of the British area consisted of vascular cryptogams, and of gymnosperms, associated together. Suddenly, however, we have on the geological horizon, here represented by the London Clay, a great display of dicotyledons known by their fruits, which have been preserved in great numbers, whereby many genera have been determined, in a great measure, from specimens obtained in the Isle of Sheppey. These fruits are not in this district accompanied by foliage, which, being of a more destructible character, would naturally decay in the passage down the river, which is supposed to have borne the less destructible nuts and other fruits from considerable distances. It has generally been considered that as this vegetation is evidently the growth of a warm, and, judging by analogy, even a tropical climate, the river drained some country far to the southward, from whence these fruits were derived. The discovery, however, of floras in Boreal regions prevents us from generalising in this direction. Although no foliage is preserved to us here in the London Clay of Sheppey, there is a contemporaneous deposit in the Isle of Wight, where abundance of leaves of dicotyledonous plants are spread out in a white pipe clay. These may be the leaves borne down by the river which emptied itself into the sea somewhere in the neighbourhood of Sheppey. There may be similar leaf deposits, such as the one above mentioned, which are now buried and lost sight of altogether.

It will be perceived, from what has been previously stated, that the great accumulation of vegetable remains is just as likely to have come from the north as from any other quarter. Although this is the first indication of dicotyledonous vegetation in our country, many of the Orders cannot be distinguished from those now existing. Dr. Bowerbank, many years ago, collected a great number of species from Sheppey, of which many are described in a work he published. There are no less than forty species of *Leguminaceæ*, not exactly belonging to the bean and other similar tribes, but rather allied to the *Mimosæ* and *Acaciæ*. Another group well represented here are the *Eurphorbias*, all of which are now confined to tropical forests.

It is from such facts as these that we infer the character of the climate of the period in question in this area ; by far the best inference as to climatal conditions being derived from vegetation. Amongst contemporaneous deposits on the Continent is one at Monte Bolca. In Sheppey the assemblage of fruit remains is limited to those portions which would endure transport from a distance and resist decay. Thus, there are no herbaceous and no cellular plants ; but, on the other hand, nuts of the type of the recent *Nipa* are found in great numbers—whence the term *Nipadites* applied to these fossils. They seem to have belonged to a group of small stemless palms. At the present day some of the rivers in the East Indies are quite crowded with such nuts, which are floated down into the estuaries, just as the nuts found so abundantly at Sheppey floated down the river, whose mouth may probably have been somewhere in that locality.

2. On the Mechanical Laws of the Movement of Rivers and Glaciers, and the Effect of these Agents in producing Valleys, Lakes, and the Contours of the Land just prior to the Historic Period.

By Alfred Tylor, Esq., F.G.S.

EXCURSION TO THE ISLE OF SHEPPEY.

June 7th, 1875.

Directors :—The President, William Carruthers, Esq., F.R.S.; Major F. Duncan, R.A., D.C.L., LL.D., F.G.S., &c.; and W. H. Shrubsole, Esq.

On arriving at Queensborough, the Members were met by Major Duncan and Mr. Shrubsole at the head of a large party of residents of Sheerness, and officers of the garrison. A number of carriages were promptly filled, and driven off in the direction of Warden Point, at the extreme east end of Sheppey. The lower road, through Eastchurch, was taken, and after a pleasant drive over a country at first somewhat unattractive and bare, but afterwards pretty and well timbered, with fertile vales and swelling elevations affording glimpses of the sea to the north, the procession of well-filled vehicles arrived at Warden Court, where, through the kindness of C. Payne, Esq., Major Duncan was enabled to give his guests a most hospitable welcome in a pleasant tree-shaded meadow sloping towards the sea. Here luncheon was partaken of by the entire party, numbering about eighty, the host, Major Duncan, presiding at the centre table. Addressing his guests at the conclusion of the repast, Major Duncan reminded his hearers that the object of the Excursions of the Geologists' Association was two-fold. These field-meetings brought the Members to the examples on which their studies were based, and thereby enabled them to learn their favourite science with a rapidity, accuracy, and completeness far exceeding anything mere words or ordinary teaching could effect; and, secondly, they imparted to the residents of the localities visited, an interest in the geology of their neighbourhood, and a desire to become, to some extent, conversant with the great teachings of the science. After some further remarks, as happy and humorous as they were tellingly delivered, and heartily enjoyed by his hearers, Major Duncan gave place to the President, who, on behalf of the Members, tendered his warmest thanks for the kindly words and generous hospitality of their host.

A large collection of the fossils so abundant in Sheppey, pyritized palm-fruits (*Nipadites*), stems, chelonian and fish remains, together with coprolites and crystals of selenite, exhibited by Messrs. Boughey, Hall, and Atkins, of Sheppey, invited the attention of the party before the road was taken to the cliffs, on the brink of which stands the ruins of a little church, which, not very long ago, was considered to occupy a secure position, but now so rapid is the destruction of the land by the sea, and so near is the church to the edge of the cliff, that it cannot be long before the whole structure is destroyed. Close to the ruins, and with a commanding view of the crumbling masses of London Clay forming the seaward face of Sheppey, the visitors assembled to listen to the President's account of the Flora of the London Clay of Sheppey.—(*See* page 318.)

Following Mr. Carruthers, Mr. W. H. Shrubsole, who has been resident in the island for twenty years, informed the visitors that the stems, as well as the fruits of plants, were often found. Landslips here were frequent, and were sometimes extensive, as much as five acres of land having given way at one time. There was a terrace, or lower cliff, which formed, as it were, a buttress to the upper, and, while this endured, the upper cliff remained; but when this support was destroyed by the waves, the upper cliff gave way, and so another under cliff was formed. The rapidity of the destruction of the cliffs is such, that no less than 800 tons of iron-pyrites, derived from the clay washed away by the sea, had been shipped in three months. *Septaria* are also numerous, and these calcarious masses being washed out like the pyrites, are collected on the beach, and used for the manufacture of cement.

A path along the edge of the cliff led to the course of a stream, by means of which the shore was gained, and the Members were enabled to examine the rugged face of the clay, which was well searched for fossil fruits. These, however, did not present themselves in great numbers, but specimens of pyrites, frequently encrusting portions of stems, were very common. Some chelonian remains were also found.

The London Clay, which forms almost the whole of the island of Sheppey, has been estimated by Mr. Prestwich to have a maximum thickness here of about 480 feet, and is similar in lithological character to the formation in the London Basin generally. Its dissimilarity palæontologically, is, however, very remarkable. The extraordinary number of plant remains which it contains, has been dilated upon by Mr. Carruthers (p. 318), and affords ground for concluding that near here a river emptied itself into the London Clay sea. This evidence of the proximity of land is in accordance with the fact that in the Sheppey area remains of turtles are found in abundance, while they are wanting in the London Clay of Middlesex and Surrey. Indeed, the number of species of turtle found at Sheppey is most remarkable, when it is borne in mind that, at present, in all the seas of the globe we have but few known species of *Chelone*.

The following species of turtles are enumerated in Mr. Whitaker's "Geology of the London Basin:"—

Chelone breviceps, Owen.
,, convexa, Owen.
,, cuneiceps, Owen.
,, latiscutata, Owen.
Chelone longiceps, Owen.
,, subcarinata, Bell.
,, subcristata, Owen.

Again following the path on the top of the cliff, the site of a Roman pottery-kiln was reached. Mr. George Dowker considered it to have been a "smoulder-kiln," in which clay vessels were placed with charcoal, and the fire sustained by a currrent of air passing through a channel dug in the earth. At Hensbrook a second descent to the shore was made, and the face of the cliff was then observed for a long distance to the west. Mr. Carruthers called upon his botanical lore to describe and explain the plants met with, one of which, the *Orchis mascula*, was in full flower, growing luxuriantly in a sheltered spot, and so afforded an illustration of an explanation of its reproductive organs.

The Island of Sheppey is, though mainly, not altogether composed of London Clay, for, in a few places, as at Minster, East Church, and at East End, a capping of sands has been observed, and these sands have been mapped by the Survey as the Lower Bagshot Sands, which, in other localities, overlie the London Clay. Perhaps the best exposure of these arenaceous beds in the island is the cliff section near the end of East End Lane, where they are seen overlying the London Clay, and have a thickness of about 25 feet.

At this point the party left the shore, and entering a pretty avenue of trees, found another repast prepared for them by the thoughtful kindness of their very liberal Director, Major Duncan.

The thanks of the party having been heartily given to Mr. Shrubsole, and the Honorary Secretary, Mr. Hudleston, who had carried out, with great completeness and success, the arrangements which Major Duncan had so ably planned for the comfort and instruction of his guests, the carriages in waiting were again in request, and after a rapid drive to Sheerness, the train was taken for London.

EXCURSION TO ERITH AND CRAYFORD.

JUNE 26TH, 1875.

Director.—J. LOGAN LOBLEY, Esq., F.G.S.

The sections visited on this occasion were the same as those inspected during the previous Excursion of the Association to Erith and Crayford, May 4th, 1872, a Report of which will be found in Vol. iii. of the "Proceedings," at page 83. It will, therefore, be unnecessary now to do more than state that the district visited comprises the angle of land formed by the junction of the valley of the Cray with that of the Thames. The Thames valley portion consists of Thanet Sands, with a capping of Woolwich Beds, overlying the Chalk; while the Cray valley contains very considerable beds of brick-earth and sands of Pleistocene age, reposing on the Eocene and Cretaceous formations above-named, and containing in abundance mammalian remains with the shells characteristic of Post-Pliocene river deposits.

ORDINARY MEETING, JULY 2ND, 1875.

WILLIAM CARRUTHERS, Esq., F.R.S., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

"Abstracts of the Proceedings of the Geological Society;" from that Society.

"Transactions of the Manchester Geological Society," Vol. xiii., part 10; from that Society.

"Transactions of the Woolhope Naturalists' Field Club," 1873-4; from that Club.

"Journal of the Society of Arts;" from that Society.

"Geological Survey of Colorado," by Dr. F. V. Hayden; from the Author.

The following were elected Members of the Association :—

The Rev. Henry Edward Maddock, M.A., F.G.S.; William Molyneux, Esq., F.G.S.; Walter Pearce, Esq., A.R.Sc.M.

The following Papers were read :—

1. ON SOME OF THE CAUSES WHICH HAVE HELPED TO SHAPE THE LAND ON THE NORTH WALES BORDER.

By D. C. DAVIES, Esq., F.G.S., Oswestry.

(*Paper deferred.*)

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2. THE YORKSHIRE OOLITES, Part II.

BY WILFRID H. HUDLESTON, Esq.. M.A., F.G.S., &c.

(*Paper deferred.*)

EXCURSION TO THE SITE OF THE NEW MUSEUM OF NATURAL HISTORY, SOUTH KENSINGTON.

JULY 10TH, 1875.

Director—Professor JOHN MORRIS, F.G.S.

(*Report by* W. H. HUDLESTON, Esq., M.A., F.G.S.)

Professor Morris and the party were received within the enclosure by Mr. Thos. M. Rickman, and Mr. Farquharson, who conducted them over the building now in progress.

Mr. Rickman described the plan of the building at some length, and gave details as to the dimensions and intended uses of the various apartments; after which the Members inspected several of the more accessible portions.

The party then adjourned to the excavation now opened in the Thames Valley Gravels, which have, within the area, a maximum thickness of about 20 feet, rather towards the eastern end, whilst on the west they are only 7 feet thick. Few organic remains have been discovered; but the tooth of an elephant, *Elephas primigenius*, was found at the west end, almost resting on the London Clay. The party then descended into the most recent excavation in the gravels, which have the usual character of the deposits below the Clay belt, which separates them from the Higher Level Gravels. Professor Morris gave a short account of the Quaternary deposits of the Thames Basin.

The following extract from the "Globe" contains a description of the intended building:—

"THE NEW NATURAL HISTORY MUSEUM.—The Geologists' Association on Saturday visited the new Natural History Museum in course of erection at South Kensington. The museum, when completed, is to receive the Natural History collections now in the British Museum. The building is now so far advanced that a very fair idea can be obtained of what it will be like. Although brickwork and iron are mainly used in the construction, yet all parts that will meet the eye, both inside and outside, will be cased with terra cotta, with the exception of the steps, which will be of stone. The floors will be of concrete, and nominally the building will be fireproof. The whole of the basement, which will not be open to the public, is practically above ground, and the level of the public halls, which are somewhat above the level of the roads, forms practically a first floor. The main entrance is on the south side; and there will be an inclined sweep for carriages as well as a broad flight of steps. This entrance leads into a large central hall where will be a classified typical natural history collection, which has been called an Index Collection. It is intended that there shall be examples of every known type. To the north of this is a hall for a British Collection. To the west of these central halls are seven "galleries" for palæontology, and to the east seven for the exhibition of illustrations of existing plants and animals. The two halls will be of one story only, but there will be balconies running round them ; the fourteen galleries will also be of one story only, but on the south side the building will be three stories high. The decorations form one of the most interesting features of the building. On the columns around the windows, and in some places on the walls, are natural history specimens carefully reproduced in terra cotta, from designs mainly furnished by Professor Owen and Mr. Henry Woodward, of the British Museum. Fish, plants, serpents, and birds, are all introduced ; and the monkeys on some of the columns have a very grotesque effect."

A vote of thanks was heartily accorded to Professor Morris and to Messrs. Rickman and Farquharson for their kindness and attention. At another section, about the same level, Mr. Ives had obtained remains of mammoth, ox, and red deer.

The party adjourned to the Albert Memorial. The long steps at the bottom, on the south side, are of granite from Penrhyn, in Cornwall; the blocks which terminate them are capped by pink granite, from the Isle of Mull. The steps above these are of a greyish-white felspathic rock, with dark specks and blotches. This is called the grey granite of Castle Wellan. The platforms are paved with three varieties of slabs—white Mountain Limestone, from Derbyshire; red Permian sandstone, from Mansfield; and dark slate from Charnwood Forest. Many other varieties of granite may also be noted here, of which the polished red granite from the Ross of Mull is probably the most beautiful.

EXCURSION TO EAST YORKSHIRE.

MONDAY, JULY 19TH, 1875, AND FIVE FOLLOWING DAYS.

Directors.—SIR CHARLES STRICKLAND, Bart.; Professor JOHN MORRIS, F.G.S.; C. FOX STRANGWAYS, Esq., F.G.S., of the Geological Survey; JOHN W. WOODALL, Esq., M.A., F.G.S.; and W. H. HUDLESTON, Esq., M.A., F.G.S.

(*Report by* Mr. HUDLESTON.)

The party from London, conducted by the President and Professor Morris, arrived at York early in the afternoon of Monday, where there was a considerable accession to its numbers. At the station the Members of the Association were met by Mr. Alderman

Walker, Vice-President of the Yorkshire Philosophical Society; Mr. W. Gray, F.G.S. Treasurer; Mr. W. Reed, F.G.S., Curator of the Geological Department; Mr. F. J. Walker, M.A., F.G.S.; the Rev. Canon Raine, members of Council; and Mr. T. S. Noble, F.G.S., Honorary Secretary. After a hearty welcome, the members of the Yorkshire Philosophical Society present invited the geologists to partake of luncheon at the North-Eastern Railway Hotel. Having enjoyed the hospitality of the Yorkshire Philosophical Society, the party proceeded to inspect their Museum, where Mr. W. Reed pointed out the chief features, drawing especial attention to the collection of bones from the celebrated Kirkdale Cave, near Kirbymoorside, and to the interesting specimens from Bielbecks. Others of the party were shown the large collection of striated boulders, derived from the mountains of the North, which have been recently discovered during the extensive excavations made for the new railway station; whilst a third party was conducted over the antiquarian department, by the Rev. Canon Raine. Owing to a pressure of time, only a cursory inspection was made of the numerous contents of the Museum; after which several of the Members made a hurried inspection of the Minster, and others visited the splendid geological collection of Mr. Reed, and the very interesting one which Mr. J. F. Walker has also formed. The party proceeded to Whitby in the evening, and took up quarters at the Crown Hotel.

On the following day a portion of them visited the Whitby Museum, where their President, William Carruthers, Esq., F.R.S., took the opportunity of examining some of the Oolitic plants in the collection. The bulk of the party inspected the fine exposure of Upper Lias on the south side of Whitby Harbour, together with the overlying Dogger and Lower Estuarine series of the Inferior Oolitic, remarkable for the great fossil mares' tails (*Equisetites columnare*) which it contains. Whilst the main party were examining the north part of the town, and seeking admission to the Museum, some crossed the bridge to the older part of Whitby, with its steep and narrow streets. Mounting the hill-side by its long stone staircase, the visitors reached the fine old Church, debased by modern windows, the elegant, though dilapidated ancient Cross, the Abbey, beautiful in ruin, and the old residence of the Cholmleys. The rain blurred the distant prospect; but traces of the ecclesiastic buildings in nearly every stone, and the suggestive surroundings, were goodly food for the "scientific imagination." About noon the majority of the party proceeded by rail to Newtondale. At the railway station they were met by the two principal local Directors, Sir Charles Strickland, Bart., and C. Fox Strangways, Esq. Through the kindness of the authorities of the North-Eastern Railway Company, the train was stopped near the "Needle's Eye," and nineteen enthusiastic geologists, undeterred by the inevitable soaking in prospect, got out to follow their two gallant leaders. The remarkable gorge-like character of this part of Newtondale, hemmed in by mural precipices which spring from steeply-wooded slopes, could be only partially realised. These precipices consist of Kelloway Rock, which here attains a very great importance, being from 70 to 80 feet thick. Ages ago this gorge was celebrated for its breed of falcons, and Yewdale Scar, to judge from its appearance, would be a favourite nesting-place. It consists wholly of Kelloway Rock, resting immediately upon the Blue-shales above the Cornbrash. At the base is a soft sandrock, which weathers into a natural corridor; thence upwards is a series of horizontal slabs of natural masonry, alternating with layers of a softer material, and occasionally with rows of circular cavities, due to the dissolving out of sphæroidal masses more soluble than the rest of the rock. There are few more picturesque precipices in all these moorlands. The brownish yellow tint of the rock contrasts well with the grey colour of the lichens, whilst the cliff face itself is bristling with dwarf oak, birch, and holly. Arrived on the summit, the party, in the midst of a drenching shower, skirted the moorland edge of the precipitous escarpment, in the direction of Levisham Station. Before arriving there an old iron mine in the Cornbrash, near Skelton Tower, was visited, and an extraordinary number of characteristic fossils obtained. This division of the party concluded the work of the day in the Pickering quarries, which, taken together, present a most remarkable and complete section of the Upper Calcareous Grit, Coralline Oolite, and passage beds connecting the latter with the Lower Calcareous Grit. At Pickering, whilst several of the party who came direct from Whitby hastened to the quarries of Coralline Oolite, some visited the grand old Castle. Scarborough was reached in the evening, and the whole party re-assembled at the Pavilion Hotel.

On Wednesday, the members of the excursion, with several gentlemen from Malton, Driffield, &c., about thirty-six in all, drove to Peak Hall, and descended the cliffs on the north side. Those who have ever had an opportunity of visiting this magnificent scene, wonderful alike for its impressive grandeur, and for the lessons which it teaches, will be ready to admit that this great group of cliffs is unequalled in our island for its combination of impressive scenery with the advantage of geological section. The fault which brings the Middle Lias on a level with the Lower Estuarine beds of the Inferior Oolite, is admirably seen about half-way down the cliff. At this point the general section on the eastern or down-throw side was explained, and the very remarkable difference of development which some of the beds undergo in those short distances pointed out.* The great feature of interest in this respect is the extraordinary importance of the passage-beds between the Upper Lias and the Oolites. On first touching the beach, here terribly stony and difficult, the alum-rock of the Upper Lias is seen in position, but as the beds are dipping rather fast in a south-east direction towards Blea Wyke Point, higher beds succeed, containing a peculiar set of ammonites. Some very fine specimens of *Trigonia literata* were here found; and above this, again, a thick series of grey sandy shales, from which specimens of *Ammonites striatulus* were obtained. The bay at Blea Wyke is hollowed out of these shales, above which occur the micaceous sands with *Lingula Beanii*, which form the scar of that singular platform. At the corner, the "Yellow sands" form the base of the cliff; and in the top of these is the *Terebratula*-bed, which is separated from the true Dogger by a band of shale. Still proceeding south-east, as the bed dips rapidly, the whole of the Dogger, here about thirty-three feet thick, came within reach of the hammers of the party. The *Nerinæa*-bed, towards the top, contains a splendid series of fossils. But these hard slabs of ironstone take much working; and, although the tinkling of many hammers was heard, few bags were enriched. It seems almost a pity to chip these exquisite frescoes, which reveal to us the life of a former world, unless the specimens can be removed and cleaned systematically. Just above the spot where the Dogger sinks into the sea, the party met a very welcome friend, which had come round by another path—the lunch. After discussing this, and listening to the remarks of Professor Morris on the general section, and to the other leaders of the party, the Members set to work upon the cliff in front, which had to be ascended ere they could win their carriages. Viewed from below, this portion of the great Staintondale range is equally instructive, if less terrible, than that along the base of which the party had already scrambled. In ascending order, there is a huge series of alternate shales and sandstones, indistinctly parted by the last feeble indications of the *Millepore*-bed, which barely survives to crop out at Peak. In the upper part of the cliff is the great marine deposit of the Scarborough Limestone, capped by shales full of *Avicula*, and surmounted by a few feet of the Upper Estuarine beds.

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* See "Proceedings Geologists' Association," Vol, iii, p. 294, *et seq.*

On Thursday morning, the weather was so bad that the party adjourned to the Museum of the Scarborough Philosophical Society, which was then thrown open to the Members by the liberality of the Council. Mr. Roberts was in attendance, and afforded every facility for examining the specimens. The leaders of the party took the opportunity of making a few observations.

Mr. Carruthers gave a sketch of the plant life of the Oolites of Yorkshire, as far as it had been determined from the remains found in the rocks. The cellular cryptogams were entirely absent, if two or three doubtful plants, which had been referred to Algæ, were excepted. The absence of cellular plants was due to conditions unfavourable to their preservation. Three groups of vascular cryptogams were represented in the rocks—the mares' tails by one or two species, the club mosses by some species, and the ferns by a large number of specimens, which had been made into more species in the books than had really been found in the rocks, because sufficient allowance had not been made for variation of form and venation which occurs in different fronds of the same species, or even in different parts of the frond. Fruit-bearing specimens of several species had been found; and though the form only was preserved as a thin layer of carbon, it gave a more certain indication of the systematic position of the fossil than the venation only. The fruits indicated the presence of ferns, which could with fair reason be placed in existing groups of that order of plants. The rest of the ferns were separated into species from characters obtained from the venation—a most unsatisfactory basis for classification, but the only one generally available to the palæontologist. The higher flowering plants were represented in these rocks only by gymnosperms. No specimens had been found which could be referred to Monocotyledons or Dicotyledons. The conifers and cycads form a large portion of the plants preserved to us, yet it is certain that the record of them is very imperfect, for the stems and fruits belonging to the large series of the foliage of the cycads are absent. The separate scales of an *Araucaria* are not infrequent in the shales, and they may belong to the foliage which is often associated with them, and which has been called *Brachyphyllum*. The fruit and foliage of another conifer is not unfrequent, and a leafy branch of a plant approaching the *Cryptomeria* of Japan has been found. Among the cycads two forms of cones have been detected - one nearly allied to the cones of existing species, except that the scales were scattered on the axis; and the other an anomalous form, which had been worked out by Professor Williamson, and was extinct. The speaker had established two genera for these plants; and recognizing in some measure the labours of two Scarborough men who had done good service to geological science, he had named the first *Beania* and the second *Williamsonia*. It was very difficult to estimate the relation to living plants of the great variety of leaf forms belonging to the Cycadeæ which were found in these beds. When the fruit is found it will probably show that other types besides that of *Williamsonia* occurred in the Yorkshire Oolites.

Professor Morris reminded his audience that he had yesterday enumerated the several formations seen in the cliffs of this neighbourbood, as far as they represented the Lower Oolitic beds, from the Lias upwards to the top of the Estuarine series, including the plant-beds and coal-seams of East Yorkshire. He had pointed out their various origin, whether estuarine or marine, and how far they were equivalent with the several members of the Lower Oolite of the south of England, viz.: the Inferior Oolite, Fullers' Earth, Great Oolite, and Forest Marble. To-day, he said, they would see the strata higher in the Oolitic or Jurassic series. There would be the Cornbrash overlying the plant-beds, a remarkably persistent though thin limestone, ranging from Yorkshire to Dorsetshire; this is overlain by the *Avicula*-shales, and the bed known as the Kelloway Rock succeeds. Here we find sandy beds, about 80ft. thick, with bands of peculiar fossils, near Scarborough, and thinning away to the south. The origin of the name (from Kelloway Bridge, in Wiltshire, one of the comparatively few places where it has been well exposed) was explained, and reference made to the "Father of English Geology," William Smith, the uncle and teacher of the late lamented and illustrious John Phillips, who did so much for the geology of Yorkshire. After the Kelloway Rock had been deposited in relatively shallow and open waters, the sea of the period was invaded by mud currents from the cliffs, or from rivers, and this accumulated to the thickness of several hundred feet during a long period and over a large area, forming what is known as the Oxford Clay. Its equivalents are found under Moscow and in Northern India. The clay beds are here and elsewhere succeeded by the Coralline Oolite and its modifications of Coral Rag and Calcareous Grit, with their fossils of a somewhat Oxfordian character. How the succession of these alternating hard sandstones, limestones, soft shales, and clays, when exposed on the cliffs, were worn away into sudden scarps and sloping taluses—as well shown by the profile of the Castle Hill—the Professor illustrated by a chalk diagram. The occurrence of Glacial clay or Drift, in patches on the top of the Castle Hill was also noticed. A masterly résumé of the whole subject concluded the address.

Professor Rupert Jones, F.R.S., having been asked to add a few words on the Physical Geology of the district, added that he knew but little of this most interesting locality, except from what he had read, and what he had been so happy to learn under the excellent guidance of Professor Morris, Mr. Hudleston, Mr. Strangways, and Sir Charles Strickland, duing this excursion. He could not but be interested in the structure of the Castle Hill, as explained by Professor Morris ; and when we sought for the proximate causes of the inclination of the strata, we must have recourse to the hypothesis boldly, but yet philosophically, advanced by Dana and others, as to the crumpling of portions of the earth's crust, as one part sunk and another remained at the level, and were crushed one against the other, giving rise to the mountains and areas of continents. The attention of the party was called to the flat-topped hills of the vicinity, and their relation to an old plain of marine denudation, and to the occurrence of hard horizontal strata resisting denudation, except where faults broke them up, and gave rise to many of the valleys, and often allowed the soft clays to be squeezed out, letting down the harder beds. The many subjects for thought and investigation comprehended in these hypotheses of undulation of the strata, plains of denudation, valley formation, and deposition of strata, were suggested for the consideration of the Members.

Sir Charles Strickland regretted that he had paid so little attention to the subject of Geology for the last twenty-five years and had come to learn, rather than to teach. Still there were some points in connection with the Liassic and Oolitic beds of this district which forced themselves upon his notice, and which he might venture to indicate to the members of the party. One of these was the remarkable recurrence of analogous and even similar life forms in beds of different age, but possessed of similar mineral characters. This was particularly shown in the case of the Marlstone, Inferior Oolite, and Cornbrash, in which strong points of resemblance might be traced; and as regards the two latter, especially with an actual recurrence of many of the same species. In the Coralline Oolite, which he had made his especial study, and with whose fossils he might claim to have some acquaintance, he had come to the conclusion that there were two, or even three, very distinct sets of fossils. This peculiarity arose more from a difference of physical condition, affecting the life of the creatures, than from changes due to the lapse of time between beds of slightly different age. Thus the lower beds of this formation in Yorkshire generally consist of Oolitic limestone, and sometimes of compact or shelly limestone, the whole being generally devoid of actual coral. These beds contain a very different set of shells from the overlying Coral Rag, which, however, is irregularly distributed and unequally developed. The latter has a peculiar set of fossils, the remains of coral-haunting Mollusca, &c., and is especially rich in finely-marked univalves, and in Echinodermata of many species, which, along with numerous other shells, may be extracted from the mineralised remains of these old coral reefs.

Mr. Fox Strangways remarked, in common with the two Professors who had already spoken, upon the importance of tracing the lines to which they had alluded, as by doing so we should be able ultimately to correlate the beds stratigraphically. In this district, which was marked by strong geological features, the stratigraphy of the interior was not always easy to read. The system adopted by the Geological Survey was to commence upon the coast, where there are fine natural sections; and having completed the survey of this portion, to make use of the knowledge so obtained for the mapping of the interior. He concluded by bearing testimony to the value of the labours of the late Professor Phillips in this direction.

Mr. Hudleston had very few observations to make by way of supplementing the remarks of the speakers who had so well explained to the party the leading geological features of the district, together with its palæontology as represented in the Museum. One point of interest might be noted as having an intimate connection with the question of the division between the Lower and Middle Oolites. At Scarborough this line might be drawn (palæontologically) rather above the middle of the Kelloway Rock, which is about 80 feet thick on the North Cliff. On this horizon there seems to be the first incoming of the Cephalopoda, so extremely plentiful in the top beds, thus marking the commencement of the Oxfordian fauna in this part of Yorkshire. Until this profusion of ammonites and belemnites sets in, there is not sufficient change in the other Mollusca to suggest the necessity for a separation into the Lower and Middle Oolites. The ammonites of the Kelloway Rock, of which there is a good show in this collection, present so many varieties of form, that fully thirty species had been described therefrom, though probably this number would have to be modified, if existing views were to be carried out. There is a strong family likeness between some of the Kelloway Rock ammonites of Gristhorpe and of those of the Oxford Clay and Lower Calcareous Grit of the coast. The next great palæontological group is the Corallian, here divisible, as Sir C. Strickland had observed, into two distinct sets. Since the Corallian can no more be viewed as a separate geological epoch, but merely as representing the coral and coral mud and sand areas (not synchronous in all parts) of the Oxford-Kimmeridgian sea, the name Corallian must be deemed a mere matter of convenience, not representing a formation in time. In this way, as regards time only, the fauna of the lower portion, or Coralline Oolite, of Yorkshire might be assigned to the Oxfordian, whilst the upper portion, representing the *Cidaris florigemma* zone of continental authors, may be assigned to the Kimmeridgian.

M. Barrois afterwards informed some of the party that the Corallian of France is now classed with the Kimmeridgian.

The weather having partially cleared on the afternoon of Thursday, the party proceeded along the South Sands, beyond the Spa, where the irregular and false bedded sands of the Upper

Estuarine series are seen to rest on the ironstones of the Scarborough Limestone. This latter group forms the Scar at White Nab; here it is probably about 20 feet thick, having shrunk from 50 feet at Hundale, north of Scarborough. South of White Nab, the formation decreases in importance; and in Gristhorpe Bay, where the party last saw it, four or five feet is about the total thickness. Crossing Carnelian Bay, the fault which brings the *Millepore*-limestone against the Cornbrash at Ewe Nab, was noted; and the party, after scrambling over the enormous blocks of the former, found themselves in Cayton Bay. The fault near the Waterworks, which brings the porous Calcareous Grit against a mass of Drift clay, is probably the cause of that supply of water which is now used by the town of Scarborough. The grand semicircular section beneath High Red Cliff next fixed the attention of the party. This serves to display the Middle Oolites, as the section at Peak does the Inferior Oolites. The sudden change of beds produced by the Red Cliff fault, still further enhances the value of this section. It brings the Inferior Oolites in again; but the sedimentary beds are rapidly shrinking, and are packed into a much smaller space than further to the North. Thus, at Youn Point, the *Millepore*-limestone, followed by a variable series containing the peculiar fossils of that horizon, is overlaid by the Carbonaceous series, or Middle Estuarine, which, besides much coaly matter, contains the celebrated Plant-bed. Amongst some of the plant-shales, a well-grown *Modiola cuneata* was found. The party now ascended the slippery slopes of Gristhorpe Bay, and after being threatened by the usual bull, which frequents the pastures adjoining High Red Cliff, returned to Scarborough by the road.

Friday was devoted to Filey Bay, and the first thing examined was the great mass of blue clay beneath the Chalk, known generally as Speeton Clay. Sir Charles Strickland brought home some fine specimens of *Ancyloceras*; and, on the whole, some of the Members were pretty successful in finding characteristic fossils, such as *Belemnites jaculum*, *Gryphæa sinuata*, &c.

Professors Morris and Rupert Jones addessed the party. The former observed that the Speeton Clay comprised the Upper, Middle, and Lower Neocomian of continental authors, of which the Upper alone is represented, as the Lower Greensand, in Southern England. The Lower beds are possibly in point of time the equivalents of the Wealden. Professor Rupert Jones, F.R.S., could only express his thanks to Professor Morris for the masterly exposition of the relationship of the Neocomian formations of Yorkshire to those of the Continent, as elucidated by Mr. Judd; and of the Wealden and other freshwater and terrestrial formations to the marine deposits of that and the preceding periods. The sketch offered by the Professor of the old land once existing between the Neocomian sea of the Yorkshire area and that of the Brunswick region, opened out many thoughts about the rivers and marshes of the old time, inhabited by enormous *Dinosaurs*, and necessarily extensive and rich with animal and vegetable life. Returning towards Filey, Mr. Strangways was able to point out a portion of the Kimmeridge Clay just peeping above the sands. A visit to Filey Brigg completed the day's work. This well-known promontory presents a most remarkable section of the Lower Calcareous Grit, especially amongst the numerous caves on the north side of the Carr Naze. The singular forms, which weathering brings out upon the various blocks, were a source of endless speculation; and those remarkable concretions, which the irreverent youth of the place describe as fossil cannon balls, gave rise to a discussion so sharp as almost to cause the Members to forget that they had to deal both with tides and time tables, if they wished to leave the fascinating spot. This most successful excursion was brought to a close by a remarkably good dinner, given by Sir Charles Strickland, at the Pavilion Hotel, Scarborough. Dr. Lycett, Mr. W. Woodall, and Mr. Teale joined the party on this occasion. Lady Strickland received the gentlemen after dinner.

On Saturday morning some of the Members left early; but about a score accompanied Professor Morris and Mr. Hudleston round the Castle Hill, where the remarkable faulting of that area was explained, and the general section from the Kelloway Rock to the Coralline Oolite pointed out, and correlated, as far as the Lower Calcareous Grit was concerned, with that at Filey Brigg.

ORDINARY MEETING, November 5th, 1875.

William Carruthers, Esq., F.R.S., President, in the Chair.

The following Donations were announced :—

"Manual and Instructions for the Arctic Expedition," 1875; from the Lords Commissioners of the Admiralty.

"Guide to Belfast;" from the Belfast Naturalists' Field Club.

"The Brighton Aquarium: What it has done for Science," by T. W. Wonfor; from the Brighton and Sussex Natural History Society.

"Treatise on Geology," by Professor Phillips; from John Hopkinson, Esq., F.L.S., F.G.S.

"Smithsonian Report for 1873;" from the Smithsonian Institution.

"Catalogue of the Publications of the United States Geological Survey;" from Dr. T. V. Hayden.

"List of Elevations . . . . West of the Mississipi River;" from Dr. T. V. Hayden.

"Birds of the North West" [United States], by Elliott Coves; from Dr. T. V. Hayden.

"Contributions to the Fossil Flora of the Western Territories: Part 1, The Cretaceous Flora;" by Leo Lesquereux; from Dr. T. V. Hayden.

"The Geological Survey of Ohio—Reports on the Counties of Tandusky, Teneca, Wyandot, and Marion," by N. H. Winchell; from the Author.

"On the Hamilton in Ohio," by N. H. Winchell; from the Author.

"Notes on the Drift Soils of Minnesota," by N. H. Winchell; from the Author.

"The Economic Geology [of part] . . . . of the State of Michigan," by N. H. Winchell; from the Author.

"The Glacial Features of Green Bay of Lake Michigan," by N. H. Winchell; from the Author.

"Annual Report of the Geological and Natural History Survey of Minnesota," by N. H. Winchell and S. F. Peckham; from N. H. Winchell.

"Report of the Geological Survey of the State of Missouri, 1874," by G. C. Broadhead; from the Author.

"Atlas accompanying Reports of Missouri Geological Survey, 1874," by G. C. Broadhead; from the Author.

"Remarks on the Sedimentary Formations of New South Wales," by the Rev. W. B. Clarke: from the Author.

"Map of New South Wales, Australia;" from the Publisher.

"La Zone a *Belemnites plenus*," by M. Charles Barrois; from the Author.

"Sur le *Byssacanthus Gosseleti*, Plagiostome du Devonien de L'Ardenne," by M. C. Barrois; from the Author.

"Quarterly Journal of the Geological Society," Vol. xxxi., Part 3; from that Society.

"Abstracts of the Proceedings of the Geological Society of London," No. 305; from that Society.

"Journal of the Quekett Microscopical Club," No. 29; from that Club.

"Transactions of the Royal Irish Academy," Vol. xxiv., Part 9; Vol. xxv., Parts 5 to 19; from that Academy.

"Proceedings of the Royal Irish Academy," Series 2, Vol. i., Parts 9 and 10; Vol. ii., Parts 1 to 3; from that Academy.

"Transactions of the Geological Society of Glasgow," Vol. v., Part 1; from that Society.

"Proceedings of the Liverpool Geological Society," Vol. iii., Part 1; from that Society.

"Transactions of the Watford Natural History Society," Vol. i., Part 1; from that Society.

"Proceedings of the Bristol Naturalists' Society," New Series, Vol. i., Part 2, and Laws; from that Society.

"Proceedings of the Belfast Naturalists' Field Club," New Series, Vol. i., Part 1; from that Club.

"Proceedings of the Berwickshire Naturalists' Club," Vol. vii., Part 2; from that Club.

"Annual Report of the Warwickshire Natural History and Archæological Society" for 1874; from that Society.

"Annual Report of the Royal Cornwall Polytechnic Society for 1874; from that Society.

"Programme and Arrangements of the Ninth Annual Excursion of the Yorkshire Archæological and Topographical Association;" from that Association.

"Journal of the Society of Arts," June to October, 1875; from that Society.

The following were elected Members of the Association:—

The Rev. J. F. Blake, M.A., F.G.S.; Richard Mackley Boorne, Esq., F.G.S.; F. H. Lyell, Esq.; W. H. Shrubsole, Esq.; F. J. Thairlwall, Esq., M. Wat. Nat. His. Soc.; Rev. William Tubb.

The President then delivered the OPENING ADDRESS OF THE SESSION 1875-6, the publication of which is deferred.

ORDINARY MEETING, DECEMBER 3RD, 1875.

WILLIAM CARRUTHERS, Esq., F.R.S., President, in the Chair.

The following Donations were announced:—

"Quarterly Journal of the Geological Society," Vol. xxxi., Part 4; from that Society.

"Abstracts of the Proceedings of the Geological Society," Nos. 305 and 306; from that Society.

"List of the Geological Society, 1875;" from that Society.

"Proceedings of the Literary and Philosophical Society of Liverpool," No. 29; from that Society.

"Proceedings of the South Wales Institute of Engineers," Vol. ix., No. 3; from that Institute.

"Transactions of the Watford Natural History Society," Vol. i., Part 2; from that Society.

"Journal of the Society of Arts, November, 1875;" from that Society.

"Description Géologique de la Craie de L'Isle de Wight," by M. C. Barrois; from the Author.

"The Comrie Earthquakes," by James Drummond; from Hyde Clarke, Esq., M.A.I.

"The Cretaceous Rocks of England," by J. Logan Lobley, F.G.S.; from the Author.

"Lecture on the Geology of Croydon," by Professor John Morris, F.G.S.; from the Author.

"The Potton and Wicken Phosphatic Deposits," by J. Harris Teale, B.A., F.G.S.; from the Author.

"Guide to the Geology of London and the Neighbourhood," by W. Whitaker, B.A., F.G.S.; from the Author.

The following were elected Members of the Association:—

Mrs. William Barber; Richard Davison, Esq.; Miss E. G. Evans; William Jerome Harrison, Esq.; Miss H. M. Jones; S. W. Kindersley, Esq.; John Robert Mortimer, Esq.; Frank Robarts, Esq.; John Steriker, Esq.; Richard Wood, Esq., M.D.

The following Paper was read:—

ON QUARTZ, CHALCEDONY, AGATE, FLINT, CHERT, JASPER, AND OTHER FORMS OF SILICA GEOLOGICALLY CONSIDERED.

By Professor T. RUPERT JONES, F.R.S., Hon. Member and Vice-President of the Geologists' Association.

(*Paper deferred.*)

ON SOME OF THE CAUSES WHICH HAVE HELPED TO SHAPE THE LAND ON THE NORTH WALES BORDER.

By D. C. DAVIES, Esq., F.G.S.

(*Read July 2nd,* 1875).

To describe the whole of the causes which have contributed to the final configuration of the land, would be to write the geologic history of all time—to describe the whole of the phenomena of each geologic epoch; to recount all the forces of deposition and denudation, of elevation and depression, of the crumpling and displacement of strata, of the action of air, rivers and sea which, during the piling up of each great group of strata, gave a configuration of its own to the surface of the land, before it was covered in its turn by the deposits of the succeeding era. It would also be to trace the connection, and to define the position, of each of these successive sets of forces in the great chain of causes that stretches through the almost boundless expanse of geologic time.

The author's object in this paper is to seek to lay down a few general principles, and to select from the stratification of the district under notice, an illustration of the operation of each of the forces by which the present surface of the land has received its configuration, and to assign to each of these, as nearly as possible, the proportion of change due to its operation.

By doing this, data will be obtained, I think, by which we may discover the forces which have been at work in the successive periods of the Earth's history, and the relative position each has occupied in the order of the forces by which from period to period, the surface of the land has been shaped.

Before I select examples of the effects produced by specific causes in the district under notice, I wish to offer a few general observations on the relation which physical disturbance bears to denudation, and also to rock appearances, which are usually assigned to denudation in its various forms.

Let A B, Fig. 1, represent a group of strata as they lie in the horizontal position in which they were originally deposited; then suppose that a force acting from below, elevates the strata into the curved position shewn in Fig. 2. Now, in the process of elevation, some or other of the following effects would be produced :—

FIG. 1.

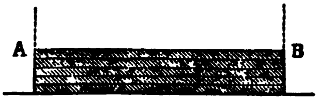
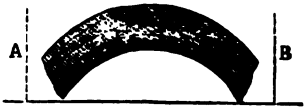


FIG. 2.



1st. If the group of strata were a rope instead, having two loose ends, the effect of the elevation of it into a curve, or series of curves, would be to withdraw the ends from the points A and B a distance which would be commensurate with the amount of the departure of the rope from a straight line, as in Fig. 2. But the extremities of a group of strata are not usually loose, but are fastened beneath the weight of superincumbent strata. Therefore, if (2nd) the group of strata be plastic, and the force be slow, it may be elevated in one unbroken curve; but wherever the group is most plastic, or the strain is the greatest, it would be attenuated in

FIG. 3.

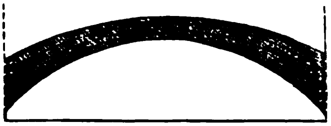
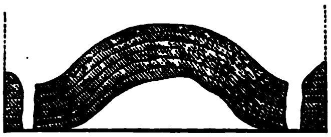


FIG. 4.



thickness, as in Fig. 3, to make up for the distance which it would otherwise be drawn in at the ends. Or (3rd), if the group were hard and brittle, and the force, either vertical or horizontal, were sudden, then a fracture, or a series of fractures, must of necessity take place. These might take place (*a*), as in Fig. 4, away from the curve on one or both sides of it. The effect of this would be to produce troughs or valleys in perfectly horizontal strata; or (*b*), if weakest, the strata might crack in several places over the arc of the curve (Fig. 5)—this would give a series of small valleys in an elevated region—or (*c*) one great central crack might result (Fig. 6), producing a valley equal in width to the combined width of the lesser cracks; or, even as in Fig. 7, giving a duplicate succession of nearly vertical beds dipping away from a centre.

Fig. 5.

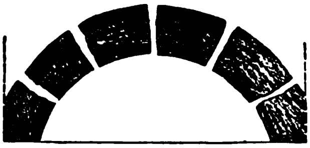
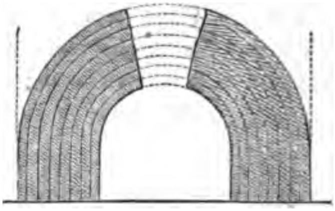
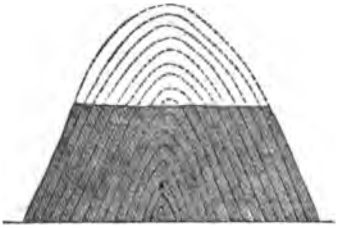


Fig. 6.



Supposing we are correct, thus far, then it follows: 1st. That the valleys and gorges on the horizontal strata (Fig. 4) would not be due *primarily* to erosion; hence we may infer that valleys and gorges, in apparently undisturbed horizontal strata, may not be *necessarily* due to denuding and erosive action. 2nd. It does not follow that when strata present the appearances shown in Fig. 7, they were necessarily once continuous over the whole curve shown by the dotted line; and, further, 3rd, that when strata were once so con-

Fig. 7.



tinuous, there was an attenuation or withdrawal somewhere or other equal to the difference in length between a horizontal and a curved line. 4th. It will be seen that where, as in a mountainous region, we have a network of valleys, great and small, the conformation of these (Fig. 5) was probably due to physical disturbance, which prepared the way for streams and glaciers which would perforce travel along the lines of weakest resistance.

If the foregoing remarks appear trite and commonplace, I would simply remind those to whom they so appear how often in geological books and papers these simple truisms of geological mechanics are almost completely ignored or forgotten.

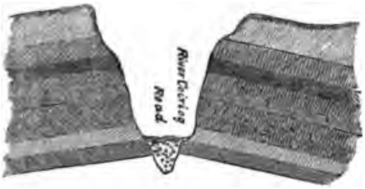
I now proceed to select a few examples from the geology of the North Wales Border of the special causes which have helped to shape the surface of the land.

It is a region of great and varied beauty. Standing in the north-west corner of Shropshire, on the high land about Ifton and St. Martin's, the spectator sees, looking south, Breidden Hill with its felspathic ashes and traps rising abruptly out of the plain of the Severn, up which valley he looks to the hilly Cambro-Silurian region about Welshpool. Nearer to him, in the same direction, he sees the bold headland of Llanymynech Hill—the southernmost point of the belt of Carboniferous Limestone, which stretches from thence northwards to the Irish Sea. Still nearer, Sweeney Mountain marks the southern termination of the Millstone Grit, which, in a series of hills, partly covers the limestone belt all along its course. Looking westward, a succession of east and west valleys afford glimpses of the limestone escarpments, and beyond these of the conical and rounded Silurian hills, which form the frontier land of Wales. Nearer to him, still looking westward, he sees, stretching north and south in chimneys and curling smoke, the line of the outcrop of the Coal Measures, which, dipping under his feet, rise again to the surface on the eastern side of the Shropshire plain. Looking eastward, across that plain, he sees afar off the most Salopian of Shropshire hills, the Wrekin, which, with its limestones abutting against felstone porphery, seems the eastern counterpart of the western hill above Selattyn. Nearer, in the east, are the Keuper Sandstone hills of Grinshill and Hawkstone, the beds of which dip down in a gentle curve until they rise to the surface again in Peckforton Hills and Delamere Forest, which are seen in the far north-east of the landscape. He should know that in the trough thus formed at the base of the Marls, which lie on the Keuper Sandstone, the great salt deposits of England are found. Thus, to the geologic eye, there are beauties and wonders in the landscape that the ordinary admirer of scenic beauty knows nothing of.

It is to some of the mountains, valleys, escarpments, and ravines, which are for the most part within the range of the spectator's vision, that I now seek to draw special attention.

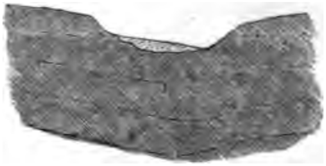
1. Valleys of Upheaval.—One of the most charming of the valleys that penetrate into the heart of the Berwyn Mountains is that of the river Ceiriog. For two miles above the village of Llansaintfraid it presents an admirable example of a valley of upheaval (Fig. 8). Looking down it, from the junction with it of the picturesque defile of the Deirw, one sees the felstones, traps, limestones, shales, and sandstones of the Bala group dipping gently away on either side from the centre of the valley, and dipping also with corresponding faces down the valley. Felstones, limestones, shales, and sandstones, answering to each other on either side—

Fig. 8.
Valley of Upheaval, Glyn Ceiriog, above New Inn.



Limestones, Shales, and Sandstones, Llandello and Bala, Cambro-Silurian.

Fig. 9.
Valley of Depression, supplemented by Erosion.
(Porthywaen).



Carboniferous Limestone.

> They stand aloof, the scars remaining,
> But neither time nor frost nor thunder
> Will wholly do away, I ween,
> The marks of that which once hath been.

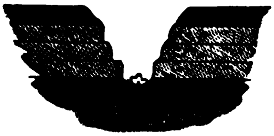
The valley at this point, it will be seen, runs along the line of a crack that has been made by the original elevation of the strata, and which crack has since been widened by erosive power.

2. Valleys of Depression.—A fair example of the way in which a valley may extend along the trough of synclinal strata is to be

seen in the valley, or pass, of Porthywaen, four miles S.W. of the town of Oswestry (Fig. 9). The massive beds of Carboniferous Limestone dip towards each other, and form a trough, along which the turnpike road from Llanrhaidr to Shrewsbury is carried. Here, too, it will be seen that the natural bend in the strata has been supplemented by erosive action.

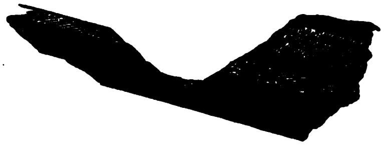
3. Valleys of Erosion.—Many nice examples of these, on a small scale, may be seen in the beds of the streams, which run from the high land about Ifton and Wynnstay, into the valleys of the Ceiriog and the Dee. Fig. 10, is an example of one of these. Larger examples may be seen in the valley of the Dee, just below Llangollen, where a passage has been cut for the river across the beds of Wenlock Shale. The valley of Rhiwarth above the village of Llangynog may also be another such example.

Fig. 10.
Valley of Erosion in Horizontal Strata.
(Pentre Glyn Morlas.)



Sandstones, Shales, Clays and Coals.
Upper Coal Measures.

Fig. 11.
Valley along Escarpment due to Erosion along line of junction between two formations.
(Craigforda.)



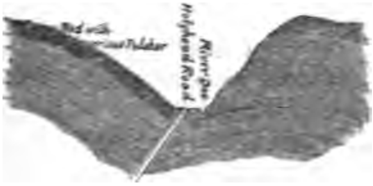
Carboniferous Limestone and Millstone Grit, capped by Coal Measures.

4. Valley eroded at the Foot of an Escarpment—Fig. 11 represents the valley of the Morda, between Llawnt and Craigforda, three miles W.N.W. of the town of Oswestry. On the one side, there is a bold escarpment of the Millstone Grit. From the other side, the Millstone Grit has disappeared, and two or three beds of the underlying limestone are cut through, and the little stream of the Morda flows at the bottom.

5. Valleys extending along the line of a Fault.—One of the most notable examples of these, in North Wales, is the valley of the Dee from its source above Bala Lake, to the town of Corwen, flowing, as the river does there, along what is known as the Great Yale Fault. I select, however, as a more compact example, the same valley at Glyn-dyfr-dwy, midway between Corwen and Llangollen. As seen in Fig. 12, there is a well-known bed of Wen-

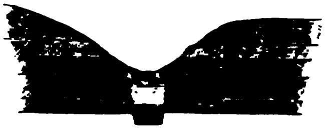
lock Shale, which from its out-crop on the west, comes dipping, down towards the bottom of the valley. On the east, however, we have to look high up for the same bed; so that we have here, either a sharp fault, as shown in the figure, or an equivalent elevation of the strata in some other form. In the trough thus made by the fault or upthrow of the beds, the valley with its river extends.

FIG. 12.
Valley along course of Fault.
(Glyn-dyfr-dwy.)



Wenlock Shale.

FIG. 13.
Valley in trough made by two parallel E. and W. Faults.
(River Dee below Wynnstay.)

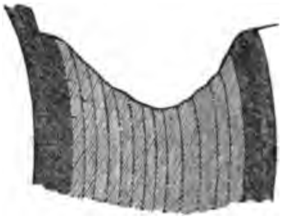


Coal Measures.

6. VALLEY IN TROUGH BETWEEN TWO FAULTS.—Fig. 13 represents a section across the valley of the Dee, above the junction of the river Ceiriog with that river. Two great east and west faults which push the whole structure of the country to the south of the Dee, a mile eastwards, course down the valley. The space between these two faults, has been let down as in the diagram, and the valley has been worn in the soft red ground lying between.

7. VALLEY OF EROSION OR DENUDATION IN SOFT STRATA, BOUNDED ON EITHER SIDE BY HARD.—Fig. 14 gives a good illustration of one of these, as it is seen at Cwmgwynen, four miles west of the town of Llanfyllin. On the left is the Hirnant, or uppermost limestone of the Bala Beds. On the right is the middle bed or Bala Limestone itself. Between are beds of soft shales, which, with the limestones, are nearly perpendicular, and in these shales a valley has been scooped out, which narrows upwards on the north, and opens out in the opposite direction.

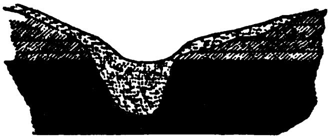
FIG. 14.
Valley of Erosion in perpendicular Strata.
(Cwmgwynen).



Bala Limestone—Cambro-Silurian.

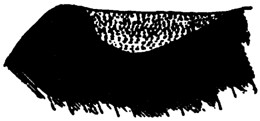
8. Fig. 15, represents an ancient rock-valley above the waterfall at Blaen Rhiwarth, above the village of Llangynog in the Berwyn Mountains. This ancient valley has since been filled up with drifted matter, in which also, a newer valley has been subsequently scooped out so far as the barrier of rock at the lower end would allow, Fig. 15A, is a longitudinal section of the same. The site of this valley adjoins a mine worked by myself, and I have proved its structure by mining operations. The older valley, or basin, is interesting, because, situated as it is in the narrow entrance to an amphitheatre among the mountains, into the further end of which several ravines converge, it has seemed to me to be a good illustration of how, on Professor Ramsay's theory, a lake may be formed in the course of a glacier, and especially, as in this case, at the confluence of several. In this rock valley, or basin, we also have what appears to me to be an essential feature of lakes claimed to be so formed, which is the barrier of rock at the lower end. Where that barrier is composed of drift, the lake has been caused simply by the damming up of the stream.

FIG. 15.
Old Valley filled with Drift. Blaen Rhiwarth, Berwyn Mountains.



Bala Limestone and Shales.

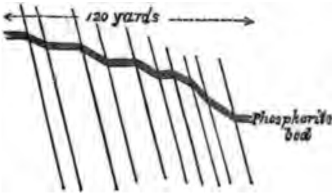
FIG. 15A.
Blaen Rhiwarth—Longitudinal Section.



Bala Limestone and Shales.

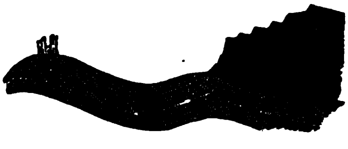
9. SMALL FAULTS.—Besides the great faults that traverse a country, there are numerous groups of minor ones, which are being constantly revealed by mining operations. In Fig. 16, I give a

FIG. 16.
Faults in Berwyn Phosphorite Mine, Berwyn Mountains.



Bala Limestone.

FIG. 17.
Llangollen—Dinas Bran and the Eglwseg Rocks.



Wenlock Shales and Carboniferous Limestone with thin parting of Old Red.

representation of a cluster of these, through which I have recently driven a tunnel in the mine just referred to, at the head of the Llangynog valley. There are nine of them within a distance of one hundred and twenty yards. The amount of the displacement of the strata by them, varies from twelve inches to twelve feet. They are clean cut faults, with cracks not more than half an inch wide, which are filled up with soft felspathic clay. They are a prolongation of the direction of the valley which, as I have before said, appears to have been worn out of apparently undisturbed strata, and I mention them here as indicative of the facility offered by such cracks to the denuding forces by which the valley has been scooped out.

10. ESCARPMENTS.—Fig. 17 gives a view of the stratification of the southern end of Eglwseg Rocks, near the town of Llangollen. The Wenlock beds below present an undulating appearance, and give one the impression that, either by their elevation on the right, or by their depression on the west, the overlying Carboniferous Limestone has been broken, and the way prepared for the subsequent sculpturing of the grand battlemented face of the limestone cliffs, that stretch away for miles to the north.

11.—In long ridges such as this we see one of the first steps in the formation of a chain of separate mountains. The next stage would be the breaking up of the continuous line of strata by cross fractures, upheavals, and depressions, by means of which a long line of escarpment becomes a series of detached, or slightly connected hills, which are then ready for the third and last stage of the process, the rounding and sculpturing of denudation. Fine examples of these various stages may be seen from the top of the Oswestry racecourse looking north, where successive ridges of Llandeilo rocks, that were once continuous, have been chopped into separate mountains and subsequently carved into cones, pyramids, domes, and all sorts of irregular and fantastic shapes.

I might adduce many more separate illustrations of actual stratigraphical conditions on the North Wales Border, but the foregoing will suffice for the present. I may now, however, add generally that in any attempt to understand the causes which have helped to shape the land in any district, note should be taken of the innumerable alterations of level, both general and local, the crust of the earth has undergone, and which, whether the movements were sudden or slow, or both, must have produced the most extensive, diverse, and complicated gaps, cracks, crumplings, and contortions in the earth's crust that we can conceive of, and one result of which at least are the numerous faults and dislocations of strata that every quarry, or colliery, or mining operation reveals.

Nor should we omit from our notice the large amount of shrinkage which has taken place in continuous strata by the heating, cooling, and consolidation of the same. Some of the effects of this shrinkage we see now in cracks and fissures running through a series of beds which are sometimes, though not always, filled with mineral matters that differ from the rest of the strata. Where this injected or infiltrated matter is harder than the surrounding rocks, the result is a dyke or ridge. Where softer, it may, when its course slopes with the watershed, form the bed of a stream, or of a glacier. In any case it presents a vertical gap for denuding forces to act upon.

From the whole of the foregoing considerations it will be inferred that the first place in point of the order of time among the agents which have been at work shaping the land must be assigned to physical disturbance. By it the land has been broken up, and rough hewn, which process has, as we have seen, in the instances cited, been followed by the ploughing and sculpturing work of denuding force.

What, then, we come now to enquire, has been that denuding, disintegrating, and erosive force by which the land has been ploughed into ridges and furrows, and cross ploughed into mountains and lakes? The simple answer is, water. Water, again, has acted in different forms—as sea, ice, rivers, and atmospheric moisture—and in all these forms with different degrees of intensity and varieties of force. Now, also, by one form alone; and, again, by two or more forms combined. These we will now briefly and separately consider.

1. The Sea.—The sea in its profound depths is the conservor of the waste of creation, and in its womb lie hidden the continents of the future. It can only be destructive when its waters, being shallow, are lashed into fury by storms, and where tidal waves ebb and flow ceaselessly. But in the innumerable alterations of levels which the surface has undergone, and some of which were slow and indefinitely prolonged, every inch of the land has been brought repeatedly within the action of this destructive phase of sea

power. Again and again has the earth "stood in the water and out of the water." In the district we are considering the mountains have been archipelagos of islands. The valleys have been inlets and arms of the sea, up and down which the tides ran, and against the sides of which the waves curled and dashed, as we may judge from the rounded hollows in the limestone cliffs in the valley of the Dee below Trevor Hall, Llangollen. The sea has washed, at almost every degree of level, the terraces of bold escarpments, around isolated hill-sides in Wales and among the lesser undulations of the Shropshire plain. Thus valleys have been widened, barriers of rock which once made each valley a chain of lakes have been broken down, hill-sides have been terraced, and the long lines of inland cliffs have been broadly marked by the action of the sea.

ICE.—Water congealed has also done its share of the work. Many geologists lay great stress upon the work wrought by the thick covering of ice that, during one or more periods, in Glacial times, covered a great part of the northern hemisphere. Yet we must not seek to attribute to this ice-cap effects which are contrary to the first principles of mechanical geology. Ice thawing, ice moving, ice in glaciers on land and floes on sea, may accomplish wonders; but ice quiescent, during its accumulation and continuance on land and sea, could not be other than a restraining force. During its reign the changeful forces of nature might well have said—" Now is the winter of our discontent."

When, too, this winter began to pass away, and the land ice, thawing and loosening, began to travel, it could only, as it seems to me, travel whither its own gravitation led it; except, indeed, where this law was reversed, when the loose ice, sliding down a longer slope, was pushed by the greater weight of the ice on such slope up one of less length and height. The mechanics are to me inexplicable by which it is supposed that such land ice travelled hither and thither of its own sweet will, utterly unmindful of those laws of force by which other agents are bound and governed. Its general effect when thus thawing and moving would be a planing—a levelling operation, by which the high points and protuberances of the land would be ground down.

It is to ice in the form of glaciers, at a period of less intense cold, and, possibly, of alternating climate, that we must look for the scooping out of the valleys that run and narrow upwards towards the summits of our mountain chains; like those I have instanced in the Berwyn Mountains. It is also to ice in floes and bergs, which, in an alternating climate, broke off from glaciers that came down to the sea; to ice splitting up rocks on the coast, and up arms of the sea; to ice, again, fastening these and carrying them away from the land, that we must chiefly look as the source of the ridges and rounded hillocks of drift that flank the frontier hills of Wales, and which have accumulated at the mouths of the valleys.

WATER IN RIVERS AND STREAMS.—These, also, have had their share in shaping the surface of the land. They have drawn the delicate lines of the beauty of the landscape which were too fine for the touch of the rougher forces just referred to. To do a great work a river must have *length* and *force*. Its work is slow, as may be inferred from the fact that, as in Figs. 15 and 15A, a rough mountain stream has not, since the last elevation of the land, worn its way through the Drift that fills up a more ancient valley. Some of the most potent effects of the erosive power of streams are to be seen in ravines of which Fig. 10 is a sample.

WATER IN THE ATMOSPHERE has given the finishing touches to the landscape—softness of outline; rounded hill-tops and graceful undulations are the slow effects of the disintegrating power of atmospheric moisture, helped, as this has been, by constant variations in temperature, with constantly-recurring frosts. One thing should always be borne in mind when we attempt to estimate the extent of atmospheric waste, which is this: the longer it is continued, the more does it check its own progress, and diminish its own power, by covering the land with vegetation, through which it can hardly act upon the underlying substances.

It is an open question whether there is evidence in geological phenomena of an earlier period of cold so intense, and especially of such duration, as that which we distinctively term Glacial. With this exception, if it be one, the causes I have enumerated have been at work through all times, stripping off the geological groups of strata that now make up the surface, other groups which once covered them. They acted then, as they have done more recently, separately, and also in varying degrees of combination. Some of our mountains and valleys may still preserve the outline of a very ancient configuration; but many of the features of the landscape have been sculptured in times which, geologically, may be considered recent, though they are still incalculably far from the possibility of human computation.

The contemplation of a locality like this, occupied as it is chiefly by the older rocks, serves to show the combined and inter-dependent action of all the forces described—rents, upheavals, subsidences, denudation and erosion, both atmospheric and marine, which have helped to shape the surface of the land. We are thus reminded that there is no need for us, in that spirit of favouritism which so surely indicates the limitation of our powers, to exalt the action of one set of forces at the expense of all the rest; to unnecessarily borrow from infinite periods of time what force may give, or to intensify force in order to economise time. It is nothing to us, whether a certain effect was produced in sixty thousand or in sixty million of years, only so far as we can discover the truth. Especially, therefore, is it unseemly, when men of science call each other names, as Uniformitarians and Cataclysmists, as they separately plead for a place in the great chain of forces for those agents whose properties they have more closely studied.

We should strive, in the spirit of a wise and reverent philosophy, to survey the whole array of forces, and to assign to each its true position, and proper work in the ever-unfolding plan of the infinite ages. Remembering that if the advent and existence of man on the earth is not an accident of, but an integral part of, that plan, it is more than probable that the various forces here described would work with greater intensity during the work of preparation, than would be either wise or convenient, if continued during the period of his occupation and residence.

THE YORKSHIRE OOLITES. Part II. THE MIDDLE OOLITES.

INTRODUCTION AND SECTION I.

BY WILFRID H. HUDLESTON, Esq., M.A., F.G.S., &c.

(*Read July 2nd,* 1875.)

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INTRODUCTION.

In a previous paper an attempt was made to exhibit the sequence of the rocks referred to the Lower Oolites, as they occur in North-east Yorkshire; commencing with the Dogger, and terminating with the Cornbrash, which is usually deemed the highest member of this sub-division. In this paper, therefore, I shall endeavour to describe the sequence of the beds of Oolitic age, as they occur in North-east Yorkshire, from above the top of the Cornbrash, as far as the lower portions of the Kimmeridge Clay, or rather into the Supra-Coralline formations more immediately succeeding the Coral Rag.

On the coast, where of course the sequence of the beds is more easily noted than in the interior, no stratigraphical break is observed between the top of the Cornbrash, and the beds which form the base of the Middle Oolites. Indeed, if we are to accept the coast section as our guide, there is no very marked physical break, other than what might result from a change of sediment, between the top of the Cornbrash at Scarborough, and the base of the Coralline Oolite of Filey Brigg, beyond which point the Oolites cannot be traced along the coast, except so far as they may be represented by the lower portions of the Speeton Clay of Filey Bay. Inland, however, the conformable sequence can be traced much higher, as will be seen when we come to treat of the very remarkable section at Pickering.

The sub-divisions with which we have to deal, accepting for the most part the names already in use, are, in ascending order:—

1. The Shales with *Avicula echinata*.
2. The Kelloway Rock.
3. The Oxford Clay.
4. The Lower Calcareous Grit.
5. The Coralline Oolite.
6. The Supra-Coralline beds.

These sub-divisions, it will be at once perceived, are of very unequal value, and are petrological rather than palæontological.

No. 1.—THE SHALES WITH *Avicula echinata*.—These might be claimed as belonging to the Cornbrash, and, therefore, to the Lower Oolites. The fossils, being in a poor state of preservation, have not excited much interest, and, therefore, there is no very reliable data upon which to proceed. These shales vary from about 8ft. to about 15ft. in thickness; the included remains seem to be related, in the lower portions, to the Cornbrash, whilst the upper portions, especially in one locality, present certain affinities with the Oxfordian fauna.

No. 2.—THE KELLOWAY ROCK constitutes an important subdivision of the Middle Oolites, both on the coast and in the interior. This formation is well exhibited at Scarborough, where, when all seen, it is about 80ft. thick. Proceeding south-eastwards along the coast, we again catch glimpses of it in various places, and last of all in the cliffs of Gristhorpe Bay, where, at a place called Newbiggin Wyke, it finally sinks beneath the sea, being reduced in thickness to 5ft.

Along its outcrop, westwards from Scarborough, the Kelloway Rock assumes considerable stratigraphical importance, and may be traced, as a strong belt of indurated sandstone, right across the country, occupying the base of the great escarpment which terminates the Tabular Range towards the north. In Newtondale, it forms a second precipice, conformable to the steep face of the Lower Calcareous Grit; and doubtless it is to be met with westwards from this again, as it is found in great force at the base of Roulston Scar, which overlooks the great central plain of Yorkshire. In the Howardian Hills, the position and development of this rock is not easily made out; but it seems to have lost the petrological importance which marks its outcrop in the Tabular Range.

No. 3.—The Oxford Clay.—The upper part of the last formation is hard and irony, and very full of fossils. Upon it rests a thick formation of sandy clay, which, in its lower portion, contains a considerable amount of organic remains, with the same belemnites, and some of the same ammonites, as that on which it rests. Hence the separation of the two is more petrological than biological, though of course, as physical differences began to prevail, a corresponding change in the fauna might be expected to take place. On the coast, the Oxford Clay is first seen at Scarborough, and is then, like its base, the Kelloway Rock, lost sight of for a while, or only partially seen in consequence of the dislocations which have prevailed hereabouts. But it reappears in great force in Cayton Bay, and thence forms the bulk of the cliff to within a short distance of Filey Brigg, where the deep water to the north of that prominent ledge occupies a hollow which has been excavated out of its upper beds.

Along its outcrop, westwards from Scarborough, the Oxford Clay, usually about 130ft.* thick, forms for the most part the slope of the northern escarpment of the Tabular Range with the terrace of Kelloway Rock below, and that of the Lower Calcareous Grit above. West of Newtondale, it seems to be more irregular, and then to become thin and partially replaced, before reaching the great western escarpment of the Hambletons, where Phillips† states it to be only 30ft. thick. Like most of the more mechanically-formed deposits, it has usually but moderate proportions in the Howardian Hills, but this is not always the case. For as we begin to follow the elbow of the long ellipse described by each formation in turn round the Vale of Pickering, we find the Oxford Clay in very considerable force at Ampleforth, in the valley which communicates with the central plain of Yorkshire by the gap at Coxwold. This valley, through which the Thirsk and Malton Railway runs, has been mainly excavated out of the Oxford

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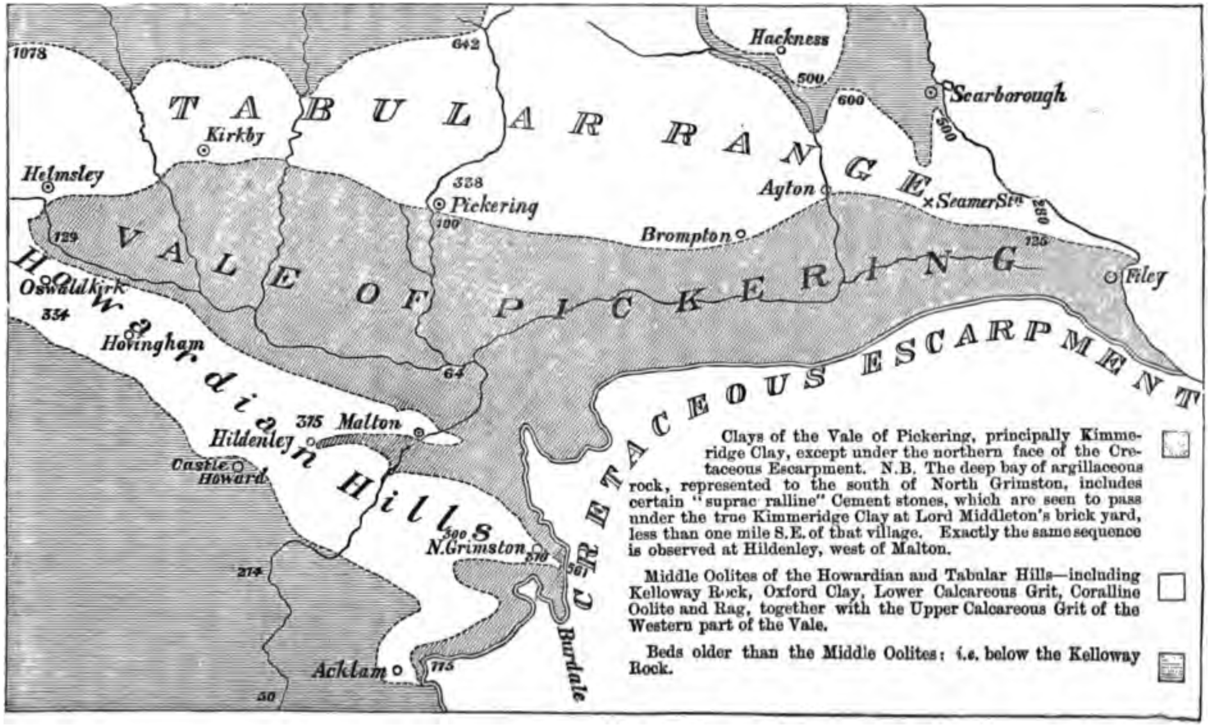
* This is probably a full estimate. Its separation from the lower portion of the overlying Calcareous Grit, can, in many cases, be only indicated by springs; and as the division in most places is by no means sharp, the estimate may vary somewhat, according to the accidents of the locality. Further west, the thickness is much less; and subject to occasional local exceptions, it may be stated generally that the so-called "Oxford Clay" of Yorkshire thickens to the S.E., and thins to the N.W. of the Oolitic area, being in this respect exactly the reverse of the so-called "Kelloway Rock." By this means a kind of compensation is established, and the thickness of the united formations are pretty nearly the same at either extremity.

† Quart. Journ. Geol. Soc., Vol. xiv., p. 91.

FIG. 8.—SKETCH MAP OF THE COUNTRY SURROUNDING THE VALE OF PICKERING



▨ Clays of the Vale of Pickering, principally Kimmeridge Clay, except under the northern face of the Cretaceous Escarpment. N.B. The deep bay of argillaceous rock, represented to the south of North Grimston, includes certain "supracoralline" Cement stones, which are seen to pass under the true Kimmeridge Clay at Lord Middleton's brick yard, less than one mile S.E. of that village. Exactly the same sequence is observed at Hildenley, west of Malton.

☐ Middle Oolites of the Howardian and Tabular Hills—including Kelloway Rock, Oxford Clay, Lower Calcareous Grit, Coralline Oolite and Rag, together with the Upper Calcareous Grit of the Western part of the Vale.

▤ Beds older than the Middle Oolites: *i.e.* below the Kelloway Rock.

Clay, which here, again, seems to attain dimensions almost equal to those observed on the coast; but the district where the Tabular Range and the Howardian Hills converge is one very difficult to understand, and must be faulted not a little. From Ampleforth the low ground is probably kept by Oxford Clay as far as where this valley debouches into the Vale of Pickering itself, but the outcrop, now facing S.S.W., instead of north, must be sought in the heart of the Howardian Hills by Wiganthorpe, Castle Howard, and Hutton Banks, at which latter place the Oxford Clay is probably 70ft. thick.

No. 4.—THE LOWER CALCAREOUS GRIT.—There is no very well-marked division between this and the last formation. The upper beds of the Oxford Clay become gradually more sandy. They are also extremely poor in organic remains; so that it may be said, speaking principally of the coast section, that there are many feet of beds, sandy clays for the most part, which form a sort of palæontological vacuum much abhorred by the collector. Where the beds harden, the more typical Lower Calcareous Grit commences. In the interior the separation may generally be traced by the increased steepness of the slope, and often by the throwing out of water. On the coast the rock is observed to assume a yellower tint, and finally presents a mural cap of hard yellow rock, which forms a fine contrast to the slaty hue of the beds below. On the dip, or coast section, it is subject to the same vicissitudes as the Oxford Clay. Usual thickness about 80 feet. The localities quoted for the last-named formation may in many cases also be noted for this. It is frequently observed to cap the summits of the Tabular Range, especially its eastern portion, and may be noted, amongst the Howardian Hills, in Hovingham and Castle Howard Parks, and at Hutton Banks and Birdsall; also between Leavening and Acklam.

The upper beds are more variable and also far more fossiliferous. Shelly and sub-oolitic limestones are often met with, alternating with sub-calcareous sandstones, the former predominating as we ascend. Thus the same difficulty again occurs, as at the base of the series, in separating it from the next formation.

No. 5.—THE CORALLINE OOLITE.*—Though nowhere exceeding a thickness of 70 feet, unless we include a portion usually alloted to the preceding formation, this is by far the most important and interesting member of the Middle Oolites, so much so, that a more detailed account of its topography is necessary, in order to make subsequent remarks intelligible.

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* The term Coralline Oolite is here used to include both the Coral Rag and the oolitic limestones, which, in Yorkshire, usually succeed the extremely variable series of beds occurring towards the upper part of the Lower Calcareous Grit. These oolitic limestones may be termed the lower

It will be remembered that in Part I. of this communication (Vol. iii., p. 286) a short outline of the physical geography of the region of the Middle Oolites was given. At page 287, Fig. 1 is intended to represent the general structure of the Tabular Hills; in that figure the Coralline Oolite is shown as a fringe of rock skirting the southern declivity of the range. If now we turn to Fig. 8, which is a sketch map of the country surrounding the Vale of Pickering, we shall find that Seamer Station (x of the diagram Fig. 1), is on the edge of that vale which is here approaching its eastern termination. It is along this edge, then, starting from Filey Brigg, and proceeding through Seamer, Ayton, Pickering, &c., that we find the best displays of Coralline Oolite on this side of the vale. But the rock creeps much higher up the slope as we proceed westward, and also increases in thickness and general development, at least as far as the neighbourhood of Pickering, where it begins to be much covered up by Supra-Coralline beds.

Continuing the circuit of the vale, we have the Coralline Oolite curving round by Helmsley and Ampleforth Beacon,* at which latter place it attains a height of 700ft., and so back by Oswaldkirk and Hovingham, to Malton. The three latter places are on the south side of the great vale, and associated more or less with the Howardian system. At Malton there is a complete gap in this inner rim of Coralline Oolite, caused probably by the very great faults which occur there. The Oolites and Rag-beds, however, soon regain the surface, and are continued, by the high ground of Langton Wold, right underneath the Chalk escarpment at North Grimston, where, singularly enough, just before it disappears, the

sub-division of the Coralline Oolite, or Coralline Oolite proper, in contradistinction to the very different overlying Coral Rag. This latter has a different fauna, due in a great measure to different physical conditions, and presents also a marked contrast, in appearance, to the Coralline Oolite. Speaking generally, the lower division of the Coralline Oolite, using that term in its more comprehensive sense, is as devoid of coral as the upper division is poor in oolitic structure. Hence the necessity for drawing some slight line of division between two series of beds, which, though linked together by many ties, present such a strong contrast both in their biological and lithological aspects.

* About the western extremity of the map, N.W. of Oswaldkirk.

Coralline Oolite attains its greatest elevation in the Howardian system proper, viz., 370ft. Here also it exhibits a thickness, and general development of its upper division, not known elsewhere in Yorkshire. At the point where the Coralline limestones of North Grimston Hill pass under the Chalk, the unconformity is so considerable, that these limestones are here within about 30ft. of the base of the Chalk, near Grimston Hill House, there being only a narrow belt of clay intervening. The post-Coralline (Kimmeridge) clay series seems nipped out altogether, though well-developed in Burdale to the South, and of prodigious thickness in the vale towards Malton. This North Grimston Hill is a continuation, though at slightly increased elevation, of the Coral Rag ridge of Langton Wold. The ridge is cut well down into the Lower Calcareous Grit by the little gorge through which the drainage of Burdale escapes at the village of North Grimston, 200ft. above the sea level.

The Oolite of Scarborough Castle Hill, is an outlier, consisting of inferior beds, which cap the Lower Calcareous Grit. There is another outlier on the plateau above Hackness. The limestones of Silpho and Suffield in this outlier belong, in their lower part, most probably to the series of the Lower Calcareous Grit; that is to say, they represent beds, which, in the majority of instances, and in typical sections, such as Scarborough Castle Hill, are usually referred to that sub-division of the Middle Oolites. Still there is something exceptional about them, inasmuch as they contain corals, which almost assume the proportions of a reef. There is another coral-bed higher in the series, as developed in the Hackness outlier, which may possibly represent the upper, or "Rag," section of the Coralline Oolite.*

No. 6.—THE SUPRA-CORALLINE BEDS.—This is an exhaustive division intended to include such portions of the beds above the Coralline Oolite,† as are found, either naturally resting upon it, or in some way or other connected with the upper part of the formation. It includes, for instance, the Calcareous Grit of Pickering, Kirkby Moorside, and Nunnington, overlying the Coralline Oolite, as well as the curious argillo-calcareous beds, locally termed "Throstler," which are so conspicuous at Pickering, and still more at North Grimston, where, however, they are called Lias. Immediately succeeding these, in all probability, is the *Ammonites mutabilis* zone of the Kimmeridge Clay. In the Howardian Hills this succession is very well made out, both at Hildenley, and at North Grimston. At the former place the Hildenley limestone, which is in that locality the equivalent of the Coral Rag, occupies high ground, and dips rapidly down the hill towards the Hall.* In the direction of the dip this limestone is succeeded by "Throstler," which has been proved in the garden, and beyond this, still in the direction of the dip, is Sir Charles Strickland's brickyard, where *Ammonites mutabilis*, *Ostrea deltoidea*, *Avicula ædilignensis*, Blake, and many highly characteristic Kimmeridge Clay fossils are abundant; the clay is also extremely seleniferous. The connection between this exposure of Kimmeridge Clay and that at Malton is, at present, only a matter of inference. At North Grimston the sequence is precisely the same: the North Grimston limestone, or equivalent of the Coral Rag, is followed on the dip by the "cement-stone," or "Throstler," which latter underlies the Kimmeridge Clay of Lord Middleton's brickyard. The relation of these clays to the Middle Oolites of the region generally involves such intricate questions, both with regard to original deposition, and subsequent stratigraphical arrangement, that we must wait till the Surveyor has pronounced his decision on the matter.

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* These beds, although probably belonging in a great measure to the Lower Calcareous Grit, will be treated in detail in Part ii, Section 2, under the head of Coralline Oolite.

† The term is here used in its more comprehensive sense, and includes the Coral Rag.

SECTION 1.

In this section it is proposed to deal in detail with THE SHALES WITH *Avicula echinata*, THE KELLOWAY ROCK, THE OXFORD CLAY, and THE LOWER CALCAREOUS GRIT. The consideration of the Coralline Oolite, Coral Rag, and Supra-Coralline beds must be reserved for a subsequent communication.

THE SHALES WITH AVICULA ECHINATA.—These Shales anticipate, to a certain extent, the physical conditions of the Oxford Clay, interrupted for a time by the great arenaceous deposit which intervenes. Considering the remarkable south-easterly attenuation of the overlying formation, the Shales are pretty uniform. At Scarborough the thickness is from 12 feet to 15 feet; in Newtondale, 10 feet. In the Hambleton escarpment argillaceous beds are mentioned by Phillips* as occurring there at the base of the Kelloway Rock, so that the formation appears to maintain itself to the westward.

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* For this, and for much other information, I am greatly indebted to Sir Charles Strickland.

Tracing the Kelloway Rock along the dip into Gristhorpe Bay, we find, in the cliff at Cunstone Nab, just before reaching the great landslip, the following section, in descending order:—

			FT.	IN.
Drift, Calcareous Grit, and Oxford Clay (about) ...			210	0
Kelloway Rock, fossiliferous bed atop wanting		measured	4	8
Blue Shales	*Avicula echinata* SHALES		9	0
Rotten Shale			1	0
Impure ferruginous limestone (Cornbrash) ...			1	0
Clays, &c., of the Upper Shale and Sandstone (about)			45	0
			270	8

A little further round the corner, at Newbiggin Wyke, where the Cornbrash and Kelloway Rock, as two little irony reefs, are lost on their dip beneath low-water mark, we have the following section on the Scar:—

	FT.	IN.
1. Hard ferruginous Sandstone, very irony atop, contains *Belemnites Owenii*, &c.	4	0
2. Fossiliferous, Sandy, and Marly Mudstone	2	6
3. Blue Shales	8	0
4. Cornbrash	1	0

No. 1 in this section is the Kelloway Sandstone. It is rather doubtful where to refer No. 2. Just below the hard reef rock we perceive masses of carbonised wood, leaves of *Zamia*, ammonites (not in good preservation, but probably belonging to the *A. ornatus* group), and masses of *Belemnites Owenii*, of all ages and sizes, stuck athwart each other like so many worms in the slippery mudstone. Palæontologically this must be referred to the Kelloway formation, as that is understood in Yorkshire. No. 3 at this place consists of grey sandy shales, with abundance of *Avicula echinata* in the upper part *Avicula echinata* also occurs in No. 2. Towards the middle of No. 3, I found *Cardium* sp., *Tancredia curtansata*, and a moderate-sized clavellate *Trigonia.*

From the above section it would seem that at this point there is a sort of inosculation of the "*Avicula*-shales" with the Kelloway group, notwithstanding the general resemblance of their fauna to that of the Cornbrash. They are, of course, somewhere on the boundary line between the Middle and Lower Oolites, as that line is drawn by English Geologists. If the series could be traced a mile or two further in a south-easterly direction, it would most likely be found in immediate contact with the Oxford Clay, the intervening arenaceous beds having entirely disappeared. In north-west Germany, where a line of Jurassic rocks stretches over a meridian of 160 miles from the Elbe to the Ems, these beds may be represented by the "Sandy-shales" containing *Avicula echinata*, which lie between the sandy and ferruginous limestones representing our Cornbrash, and the building sandstone containing the *A. macrocephalus*-beds. These "*Avicula echinata*-beds" of Germany are stated by Von Seebach to be from 20 feet to 25 feet thick at the Porta Westphalica;* and, precisely as we find to be the usual case on the Yorkshire coast, they are not sharply divided off from the building sandstone of the *A. macrocephalus*-beds. Yet it is here that Von Seebach appears to draw the line between the Middle and Upper Jura; whilst Dr. Brauns extends that line to the top of the Ornatenthone, which have their Yorkshire equivalents in the very highest part of the Kelloway Rock of Scarborough.

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* Opp. cit., page 355.

A few fossils were obtained for me from some grey marly shales, but mixed with others evidently from a Cornbrash matrix. Those from the grey marly shales, though flattened and difficult to recognise, appear to belong to the following genera and species:—

Ammonites—Ribbed fragment.
Gryphæa—young of.
Pecten lens, *Sow.*
„ demissus, *Phil.*
Lima rigidula, *Phil.*
„ sulcata, Goldf.
Avicula echinata, *Sow.*
„ sp.
Modiola cuneata, *Sow.*
Pholadomya, sp.
Gresslya peregrina, *Phil.*
Goniomya literata, *Sow.*
Waldheimia lagenalis, *Schlot.*
Rhynchonella Leedsii, Walk.
Serpula, sp.
Glyphæa Stricklandi, *Phil.*

The specimens of *Glyphæa* are found in small oval nodules, which are rather characteristic of the *Avicula*-shales. They consist for the most part of a pale buff-coloured phosphatic stone, more or less resembling potatoes, externally. The nodules examined by me are pretty rich in calcic phosphate, and many of them, also, in ferrous carbonate. Like septaria, they have shrinkage cracks, often as fine as threads, which, in no case under my notice, extend to the surface. These cracks are filled with spathic iron, associated with pyrites, and a snowy white silicate, probably allied to *Kaolinite*. There is nothing much to be learnt from this small collection, except that, on the whole, the fauna leans to Cornbrash types. The majority of the specimens are of species which have a wide Jurassic range, and whose presence in any particular formation is due principally to the nature and physical conditions attending the deposit. Their state of preservation scarcely admits of critical examination; but the specimens of terebratuloid shells have more resemblance to the form now called *Waldheimia lagenalis*, Schlot, so common in the Cornbrash, than to that shorter form of the *W. ornithocephala* group, which prevails in the Kelloway Rock, and which Mr. Walker is disposed to refer to the *W. umbonella*, of Lamarck. *Avicula echinata* is, of course, excessively abundant, and characteristic.

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* The Oolites of N.W. Germany lie about 2 degrees south of the parallel of the Yorkshire Oolites. From their western extremity, on the Ems, Scarborough bears W.N.W., 350 miles.

THE KELLOWAY ROCK.—Along a line drawn from Scarborough North Cliff to Newbiggin Wyke, a distance of about five and a-half miles, it is easy to perceive, by the rapid attenuation of this formation, how much it differs from the underlying shales in constancy. The task of following the Kelloway Rock along its dip is by no means an easy one, on account of the dislocations which prevail hereabouts. Since its formation and consolidation, the rock has been pretty well moved about; so that to follow it closely would be to write the stratigraphical history of the district. We must be content, therefore, to take it at certain points: (1) on its dip towards the south and south-east; (2) on its outcrop westwards from Scarborough.

At the North Cliff, underneath the Albion Hotel, which is about 190 feet above sea.level, we have the following section from above downwards:—

DETAILED SECTION OF THE KELLOWAY ROCK, NORTH CLIFF, SCARBOROUGH.

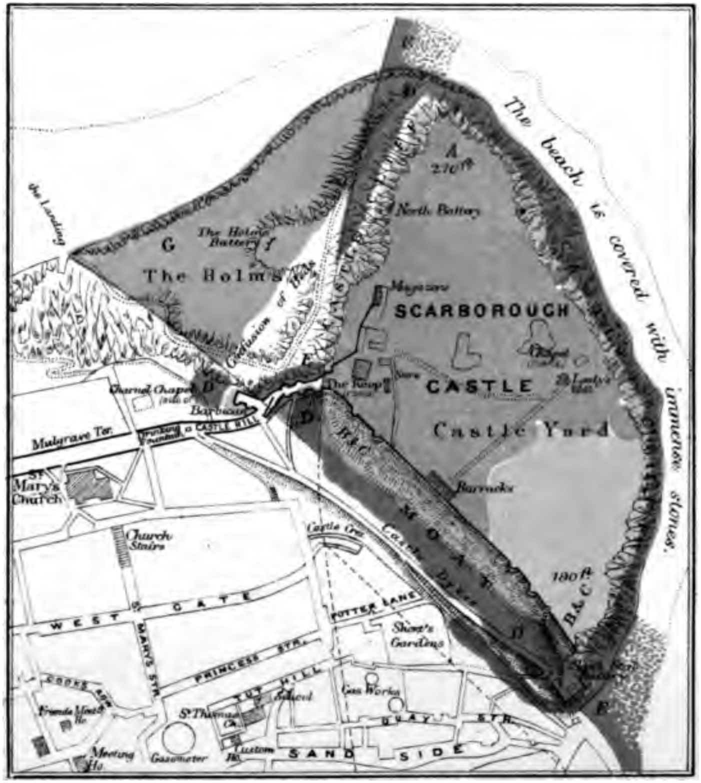
(IN DESCENDING ORDER.)

	FT.	IN.
BRASH AND BROKEN ROCK; VERY FERRUGINOUS; HARD WHERE NOT EXPOSED— Contains *Belemnites Owenii*, *Ostrea flabelloides*, *Gryphæa dilatata*, Ornatus ammonites, &c.	4	0

	FT.	IN.
UPPER TIER OF SOLID STONE— Contains a band of subcrystalline fossiliferous rock, from which many of the specimens of ammonites and other shells marked "Kelloway Rock, Scarborough," have been obtained, 1ft.; rotten irony sandstone, with similar fossils, 1ft. 6in.; building sandstone, poor in fossils, 7ft. 6in.	10	0
LOOSE MUDDY SANDSTONES— (Thickness estimated merely.)	20	0
LOWER TIER OF SOLID STONE— Contains a hard bed, charged with *Belemnites Owenii*, &c.	12	0
LOOSE CLAYEY SANDSTONES— Contain hard bands and doggers, with *Astarte* like *A. carinata*, Phil., *Trigonia Rupellensis*, *Modiola cuneata*, *Avicula Braamburiensis*, *Pholadomya Murchisoni*, &c. N.B.—Impressions of these and of other species are frequent in the lower sands.	30	0
	76	0

The upper six feet appear to contain the great mass of the fossils, for which this formation, at Scarborough and elsewhere in Yorkshire, is so famous: the freestones of the upper tier probably contain a few specimens of the same species. The lower tier of building stones seems to have foreshadowed the fauna and physical conditions which culminated during the deposition of the materials forming the upper tier. Palæontologically this lower tier may perhaps be viewed as on a level with the "fossiliferous sandy and marly mudstone," so full of *Belemnites Owenii* at Newbiggin Wyke. The lower sands at the base, which gradually melt into the *Avicula*-shales beneath, bespeak somewhat different conditions, and contain a very different fauna from the upper beds. This part of the formation is full of a peculiar doggery rock, and also of ramose bodies like sponges. It is tolerably rich in *Trigoniæ*, amongst which there is a very beautiful clavellate form, identified by Dr. Lycett as the *T. Rupellensis* of D'Orbigny's "Prodrome." I do not hear of any belemnites or ammonites having been found here. The fauna is rather estuarine, and seems to indicate a partial renewal of the physical conditions which had produced the three great Estuarine Series below the Cornbrash. There are several places about the Castle Hill outlier, where the Kelloway Rock may be studied with advantage. Close to the outer pier of the harbour there is a large exposure; there are others, also, on the north side of the Castle Hill, where, however, the fallen blocks, from which the majority of the fossils were extracted, had been so well picked

Figure 17.



—— Faults.

- - - - Possible position of faults.

A. Coralline Oolite.

B & C. Passage Beds & Lower Calcareous Grit.

D. Oxford Clay.

E. Kelloway Rock.

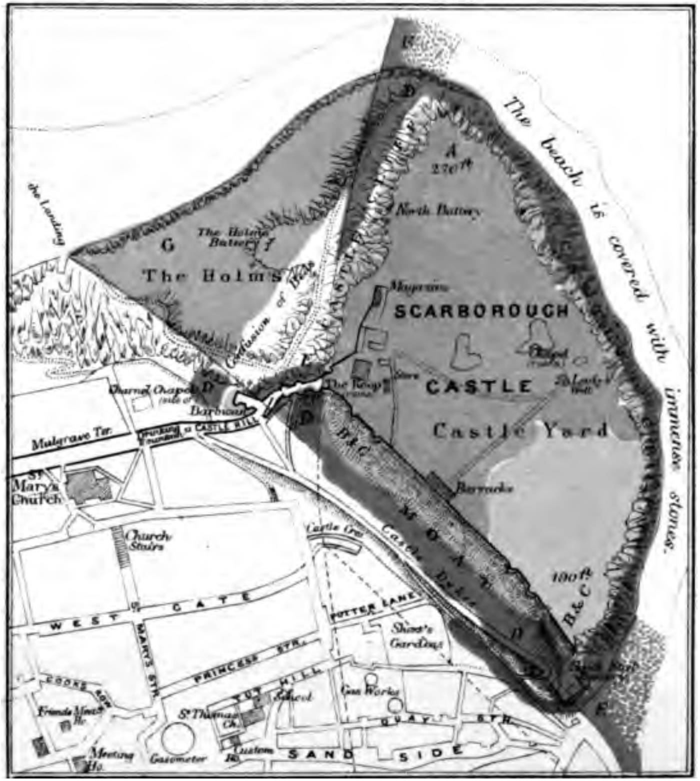
F. Shales & Cornbrash – Fragments may be seen, partly in position, between the Kelloway Rock at the Barbican and the Upper Shale & Sandstone of the Holms.

G. Upper Shale & Sandstone.

	FT.	IN.
UPPER TIER OF SOLID STONE—	10	0
Contains a band of subcrystalline fossiliferous rock, from which many of the specimens of ammonites and other shells marked "Kelloway Rock, Scarborough," have been obtained, 1ft.; rotten irony sandstone, with similar fossils, 1ft. 6in.; building sandstone, poor in fossils, 7ft. 6in.		
LOOSE MUDDY SANDSTONES—	20	0
(Thickness estimated merely.)		
LOWER TIER OF SOLID STONE—	12	0
Contains a hard bed, charged with *Belemnites Owenii*, &c.		
LOOSE CLAYEY SANDSTONES—	30	0
Contain hard bands and doggers, with *Astarte* like *A. carinata*, Phil., *Trigonia Rupellensis*, *Modiola cuneata*, *Avicula Braamburiensis*, *Pholadomya Murchisoni*, &c.		
N.B.—Impressions of these and of other species are frequent in the lower sands.		
	76	0

The upper six feet appear to contain the great mass of the fossils, for which this formation, at Scarborough and elsewhere in Yorkshire, is so famous: the freestones of the upper tier probably contain a few specimens of the same species. The lower tier of building stones seems to have foreshadowed the fauna and physical conditions which culminated during the deposition of the materials forming the upper tier. Palæontologically this lower tier may perhaps be viewed as on a level with the "fossiliferous sandy and marly mudstone," so full of *Belemnites Owenii* at Newbiggin Wyke. The lower sands at the base, which gradually melt into the *Avicula*-shales beneath, bespeak somewhat different conditions, and contain a very different fauna from the upper beds. This part of the formation is full of a peculiar doggery rock, and also of ramose bodies like sponges. It is tolerably rich in *Trigoniæ*, amongst which there is a very beautiful clavellate form, identified by Dr. Lycett as the *T. Rupellensis* of D'Orbigny's "Prodrome." I do not hear of any belemnites or ammonites having been found here. The fauna is rather estuarine, and seems to indicate a partial renewal of the physical conditions which had produced the three great Estuarine Series below the Cornbrash. There are several places about the Castle Hill outlier, where the Kelloway Rock may be studied with advantage. Close to the outer pier of the harbour there is a large exposure; there are others, also, on the north side of the Castle Hill, where, however, the fallen blocks, from which the majority of the fossils were extracted, had been so well picked

Figure 11.



—— Faults.

- - - - Possible position of faults.

A. Coralline Oolite.

B & C. Passage Beds & Lower Calcareous Grit.

D. Oxford Clay.

E. Kelloway Rock.

F. Shales & Cornbrash — Fragments may be seen, partly in position, between the Kelloway Rock at the Barbican and the Upper Shale & Sandstone of the Holms.

G. Upper Shale & Sandstone.

over when Mr. Leckenby* wrote in 1858, that, even then, there was hardly anything to be found.

Following the coast section, the next appearance of the Kelloway Rock is under Wheatcroft. Some broken and imperfect fragments may be seen about Osgodby Nab, and Tennants Cliff; beyond which, when we get clear of the drift of Cayton Bay, occurs the celebrated section under High Red Cliff. Here it forms a handsome buttress of a rich brown sandstone, which springs from the beach, and supports, like a concave wall, the dark grey shales of the Oxford Clay, capped by the yellow layers of the Lower Calcareous Grit. The average thickness in this exposure may be about thirty feet, but it appears to be thinning towards the east.

The general character of the formation here is somewhat similar to that at Scarborough, though with a less amount of loose sand, and perhaps more ironstone. The upper six feet usually contain, in a kind of ironstone, the principal fossils, such as belemnites, ammonites, gryphæas, &c., for which the locality is famous. These become less plentiful lower down; and I cannot find that they have been met with in the lower beds. About halfway down, in one of the ferruginous bands, occurs rather plentifully, but very difficult of extraction in consequence of the hardness of the stone, a little irregular *Trigonia*, belonging to the group *Undulatæ:* to this Dr. Lycett has given the name, *T. paucicosta.* In the middle and lower portions of the formation generally, we have ferruginous and calcitic doggers, often very siliceous, and hard beds of a similar composition, with *Trigonia*, *Gervillia*, and sponge-like forms, amongst sandstones containing impressions of these fossils, along with *Modiola cuneata*, *Avicula*, &c. From these facts we may gather that the Kelloway Rock of Red Cliff is divisible into two groups, an upper and truly marine one with abundance of Cephalopoda, and a lower group which is less decidedly marine in its character.† As regards the top fossiliferous beds, these are, in some cases, either wanting, or not always equally fossiliferous. The ammonites most frequent in them are *A. Gowerianus*, *A. Kœnigi*, *A. modiolaris*, and *A. Chamusseti*: no specimens of the Ornatus group are quoted from here, but *A. flexicostatus* (*Lamberti*, Sow.) is said by Mr. Leckenby to occur in the topmost bed. Towards the east end of the base of High Red Cliff, and not very far from the fault, the Kelloway section becomes more accessible, and presents the following in descending order, the thickness being estimated merely:—

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* Quart. Journ. Geol. Soc., Vol. xv., p. 6.

† Though Cephalopoda are not easy to discover in these lower beds, at Red Cliff, so full of *Trigonia* and *Gervillia*, it would not be safe to infer their entire absence, inasmuch as Sir Charles Strickland has found a very peculiarly marked ammonite, as I understand, amongst the trigonias, which are most plentiful about the middle of the band of rusty sandstone which constitutes the Kelloway Rock of this locality.

	FT.	IN.
Sandy ironstone, in some places rather crumbly. The lower three feet contain the chief fossils of the locality, principally ammonites, belemnites, and gryphæas, with a few fossils of the same kind higher up	5	6
A hard, knotty, brick-red rock, also largely charged with iron; has a few fossils similar to the bed above, but is too hard to work, projects beyond	4	6
Softer brownish yellow sands	5	0
Hard, semi-crystalline, ferruginous and calcitic sandrock, with *Trigonia paucicosta*, *Tancredia curtansata*, &c. Blocks of this rock lie about the shore; varies in thickness	1	6
Sandstone masses, very irregular, and doggery with many casts of fossils, *Gervillia* and *Modiola* especially abundant. It is probable that *Trigonia Rupellensis* also occurs on this horizon	5	6
Sandstone masses, which lower down become looser, and less like rock in character, with bad casts of *Trigonia*, *Modiola*, &c.	6	0

At High Red Cliff, we just obtain a peep of the Kelloway Rock, on the east side of the fault. In this small exposure on the upthrow side we may observe, about twelve feet from what is there the base of Kelloway Rock, a *Mya*-bed in clean yellow sand, where the large Cornbrash *Myacites* occurs, along with others of the same genus, and with a clavellate *Trigonia*. Beyond this the rock is masked by Drift, and when next it emerges into daylight is still well up in the cliffs of Gristhorpe Bay, where its thickness, by estimation, is 18 feet, at the N.W. end of the bay. From this point, a steady fall towards the S.E. is noted, and a diminishing thickness, with some irregularity of development. The top fossiliferous beds are stated to be wanting in many places. Near Pudding Hole we find the section already quoted in reference to the *Avicula*-shales.* This is immediately concealed beneath the ruins of the great landslip, and most unfortunately, for here is one of the most fossiliferous portions of the Kelloway Rock, where the upper part, usually so irony, is of a more calcareous nature, and full of oolitic grains. From this place many of the specimens marked "Gristhorpe" are obtained. Judging from the ammonites, the fauna is rather higher than that of Red Cliff. The ultimate disappearance of the Kelloway Rock in Newbiggin Wyke, as a little reef of sandy ironstone, containing *Belemnites Owenii*, Ornatus ammonites, &c., has been already mentioned. The inferior beds, with *Trigonia*, &c., so well shown at Scarborough, and even so near as Red Cliff, are either wanting here, or have become merged in the *Avicula*-shales. Although the attenuation is so great, viz., from 75 to 5 feet in about 5½ miles, the general appearance, mineral character, and to a certain extent, fossil contents of the Kelloway Rock here is much the same as obtains in the top beds of the formation at Scarborough. This attenuation gives a gradient of 1 in 415 for the natural slope of the upper surface, supposing the base to have been level originally; but this is very doubtful. Moreover, we cannot say that the coast section may not be slightly oblique both to the full dip and to the direction of greatest thinning. But it is quite safe to infer from what we have seen that the Kelloway Rock, as developed on the north side of the great vale of Pickering, constitutes a sort of wedge with the sharp edge pointing in a southerly direction. In this respect it follows the rule of the estuarine deposits of the Lower Oolites; and notwithstanding the great contrast of their fossil contents as regards the *upper* part of this formation, it must be viewed as a deposit of somewhat similar materials, and possibly derived from the same quarter.

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* See page 361.

Without attempting to trace the intervening exposures of Kelloway Rock along its line of outcrop, it may be convenient to give the following extract from my note book, containing a brief description of its character and development, as exhibited at Yewdale Scar, in Newtondale, a point about eight miles W. by N. of Hackness. "Then comes on a noble precipice, some seventy or eighty feet in height, consisting entirely of Kelloway Rock, which rests on a slope formed by about ten feet of *Avicula*-shales. At the base occurs about seven feet of a soft, greyish-yellow, variegated sandrock, weathering into a natural corridor, which would afford no mean shelter during a shower. Thence, upwards, is a series of horizontal slabs of natural masonry, alternating with insterstices of a softer material, and frequently towards the top are *A. Gowerianus*, *A. Kœnigi*, *A. modiolaris*, and *A. Chamusseti*: no specimens of the Ornatus group are quoted from here, but *A. flexicostatus* (*Lamberti*, Sow.) is said by Mr. Leckenby to occur in the topmost bed. Towards the east end of the base of High Red Cliff, and not very far from the fault, the Kelloway section becomes more accessible, and presents the following in descending order, the thickness being estimated merely:—

	FT.	IN.
Sandy ironstone, in some places rather crumbly. The lower three feet contain the chief fossils of the locality, principally ammonites, belemnites, and gryphæas, with a few fossils of the same kind higher up	5	6
A hard, knotty, brick-red rock, also largely charged with iron; has a few fossils similar to the bed above, but is too hard to work, projects beyond	4	6
Softer brownish yellow sands	5	0
Hard, semi-crystalline, ferruginous and calcitic sandrock, with *Trigonia paucicosta*, *Tancredia curtansata*, &c. Blocks of this rock lie about the shore; varies in thickness	1	6
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The upper portions of the "Rock," which on the coast present a considerable amount of the salts of lime and iron, seem in this exposed situation to have been so drenched by acidulated waters, generated in excess through the decomposition of the moorland peat, that a bare and meagre grit with casts of fossils occupies the edge of the plateau. When not exposed to this action some of the beds in this wild region of Goathland, where the outcrop of the rock attains its most northerly point, are stated by Bewicke to contain valuable ironstone. It is remarkable, also, for the great quantity of vegetable impressions and woody fragments associated with these—another connecting link between this deposit and the Estuarine-beds of the Lower Oolites. We have already had occasion to note this peculiarity at Gristhorpe. An extract from Bewicke's account of the ironstones in the upper part of the Goathland Beck, near Killing Pits, which he seems to refer to the Kelloway Rock series, may prove of interest. It should be stated that the Killing Pits have been the puzzle of antiquaries for a long time. Bewicke† believes them "to be nothing more than the rude remains of mining operations carried on in this deposit in that bleak and barren region in ages long gone by." These pits, according to him, consist of a series of excavations formed in parallel rows, extending along the brow of a hill, the interior of which consists of grey shale, identical, he believes, with the Oxford Clay of Phillips. The "Upper Oolitic" (Kelloway Rock ?) ironstone is stated to be found at the bottom of this. Subjoined is an extract taken from his large section:—

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* Killingnoble Scar, which is opposite, was famed for its breed of falcons, for the preservation of which special enactments were made.

† "Geological Treatise on Cleveland," page 77.

Grey Shale, the Oxford Clay of Phillips.
Presumed equivalents of the Kelloway Rock.
Nodular ironstone.
Flagstone mixed with vegetable impressions.
Grey shale.
Ironstone.
Flagstone.
Blue Shales above the Cornbrash?

According to his scale, the total thickness would be about seventy feet. This is believed to be a generalized section not to be proved in any one place.* One peculiarity is that Bewicke seems to have considered these ironstones to consist of a richer ore than is usually met with in that part of the country.

From this district the outcrop of the Middle Oolites has a strong southerly deflection for a few miles, but soon regains its general westerly trend until finally cut off, about twenty miles W.S.W. of Goathland, by the great Hambleton escarpment, where, as previously stated, the Kelloway Rock, or arenaceous member of the Lower Oxfordian, is very thick. Reference has already been made in a foot note, page 355, to the extraordinary reversal in the relative thickness of the "Kelloway Rock" and of the "Oxford Clay" on the coast, and in the inland or western escarpment. It has also been shown how on the coast itself this thinning of the Kelloway Rock only takes place in a southerly or south easterly direction. Where the section at the northern and western outcrops presents what we may almost term the thick end of a wedge, it is difficult to avoid speculating upon the possible extension and thickening of these brown sandstones almost indefinitely towards the N.W. As the traveller bound for the north glides swiftly, in the fastest of trains, through the great central plain of Yorkshire, he sees high upon his right, if the day be fine, the mural cliffs of Oxfordian age, which cap the great escarpment of the Hambletons. If he knows anything of the history of their development, and how that a mere strip of Oxford Clay, some thirty feet thick, is squeezed in between a hundred feet of brown Kelloway sandstone below, and a hundred feet of Calcareous Grit above; if then he remembers how this brown sandstone thins away to the south and east, let him carry in his mind's eye its north-westerly extension right across the blue vault above his head until, its full proportions, in no vain imagination, once more restored, he sees this old Oxfordian shore deposit reposing on the flanks, though not in actual contact with the Upper Palæozoic rocks, whose remains may be seen to bound the western horizon. If we could write the history of what has been, guided by the analogy of what is, we might possibly thus arrive at a point where the upper and lower sandstones of Oxfordian age should coalesce, and no clays be left to represent the physical conditions of that great argillaceous deposit which extends across our island in almost unbroken continuity from Scarborough to Weymouth. This thinning of beds with the dip has been well treated of by Mr. Topley* as regards the Jurassic and Triassic rocks of central and southern England. He also alludes to the Oolitic rocks of Yorkshire. There can be no doubt whatever that the thinning of beds along their dip, producing an appearance of upheaval, is an important element in the surface configuration of a district, and nowhere more so than in the Oolitic area of Eastern Yorkshire. It must be classed along with "disturbance" and "denudation," as one of the principal causes in producing those existing results which we may term "accidents of the surface." The subject will be adverted to more fully, especially as regards the Vale of Pickering, under the head of Coralline Oolite. The identification of the Kelloway Rock in the Howardian Hills is not very satisfactory. (See "Yorkshire Oolites, Part I." Proc. Geol. Assoc., Vol. iii., p. 332.)

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* I regret very much not to have had an opportunity of visiting this locality. Killing Pits bear N.W. from Yewdale Scar rather over 3¼ miles.

MINERAL COMPOSITION.—The general composition of the Kelloway Rock is that of a brownish sandstone, with varying shades of colour, inclining to red and yellow. This arises from certain modifications in the character and decomposition of the cementing matter, which thus produces an irregular and lumpy appearance in the beds. The material is usually an extremely rounded quartzoze sand, with a muddy investment. The lower beds are often feebly coherent, whilst in the upper and more fossiliferous portions there are considerable accumulations of lime and iron. This description is intended to apply principally to the rock as seen on the coast. Near the pier at the base of Scarborough Castle Hill, and again at the North Steel, some of the peculiar mineral conditions of this rock may be noticed. The North Steel is a low promontory which protects the Castle Hill from the north-easterly swell of the German Ocean. It consists of the upper beds of the Kelloway Rock sharply cut off on the west by the Castle Cliff fault, and running out into the sea like an immense natural groin.* Nowhere, perhaps, in Yorkshire, is there such an excellent example of the protecting power of a good pier of ironstone. Visited at low water, it appears as a deeply-fissured platform—a sort of *mer de glace*, in stone, forming a prominence upon the Scar, and rather bulging seawards, as though glad to be relieved of the pressure of the Castle Hill. Some fantastic projections, the remains of the uppermost beds, are noticeable features; these are the results of unequal weathering, due, in a great measure, to varying proportions of the cementing material. The ironstone is lumpy and irregular, and probably too lean and siliceous to be of much commercial value. A fragment taken from here may be described as a nest of shells, principally *Rhynchonella*, in a brick-red nodular matrix, with a grey core. The shells are a mixture of ferrous and calcic carbonates, in a spathic condition, and this is the state of many of the best preserved fossils of the Kelloway Rock of Scarborough. Another fragment consists of a paste or matrix of ferrous and calcic carbonates, a little mud, and some fine sand. The paste includes a quantity of discoidal and oviform grains, giving the rock somewhat of an oolitic appearance. These grains are not altogether soluble in acid; the composition is probably that of a mixed, hydrated silicate. The more flattened grains under the lens exhibit, on the surface, a number of shallow depressions.

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* W. Topley, on "Areas of Apparent Upheaval." Quart. Journ. Geol. Soc., Vol. xxx., p. 186.

FOSSIL CONTENTS.—Besides the difference already noted between the upper and lower beds of the petrological group known as the Kelloway Rock, the Upper, or Cephalopoda division, seems to contain ammonites belonging to two geological divisions, of which *A. modiolaris* (Lhuid), and *A. Gowerianus* (Sow.), represent callovian forms, whilst *A. Duncani* (Sow.), *A. Jason,* Reinecke (*A. Gulielmi*, Sow.), *A. Lamberti* (Sow.), and many others, are characteristic of the Ornatus-clays, or Lower Oxfordian. But it is quite possible that distinctions which may suit one region cannot be so sharply drawn in another. Still, in order to prevent mistakes arising from names, it is necessary to point out that the fauna of the upper part of the Kelloway Rock of Yorkshire, as indicated by its ammonites, embraces much of the Oxfordian of English geologists. Then arises the question: Are the fossiliferous (Cephalopoda) beds in the upper part of the Kelloway Rock at Scarborough, at Red Cliff, and at Gristhorpe, wholly contemporaneous deposits? At Scarborough the ornati seem to be very plentiful; at Red Cliff, *A. Gowerianus*, &c.; at Gristhorpe the cordati, as *A. vertumnus*, Leck, (*A. Mariæ*, D'Orb.), and *A. flexicostatus* Phill (*A. Lamberti*, Sow.), &c. This question can only be settled by a very close attention to the precise position of specimens collected during a considerable lapse of time.

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* See Fig. 11, in Plate.

The conditions of deposit, as may be inferred from previous statements, were probably those of a sandbank, more or less connected with the shore, the land supplying the material lying somewhere to the north and west. From the fact of there being a great thickness of brownish sands with *Trigonia*, *Modiola*, *Avicula*, &c., at the base of the series, both at Scarborough and at Red Cliff, whilst this cannot be traced to Gristhorpe, we are rather led to suppose that the northerly portions of this Jurassic sandbank are of older date than those to the southward; but this applies only to the base of the series. The deposition of the upper portions alone extended over a period sufficiently long to intercept and entomb amongst other remains the ammonites of two horizons which seem to have been distinguished in other districts.

Subjoined is a list of the commoner and more easily procurable fossils. For further particulars consult Leckenby,* in the "Quarterly Journal of the Geological Society," especially as to peculiar forms of Ammonites:—

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* Opp. cit., page 365.

FOSSILS OF THE KELLOWAY ROCK OF THE YORKSHIRE COAST.

Sc., Scarborough. R., Red Cliff. Gr., Gristhorpe.

Belemnites Owenii, Pratt.
„ hastatus, Blainville.
Nautilus hexagonus, Sow.
Ammonites modiolaris, Lhuid. R.
„ Gowerianus, Sow. Sc. R.
„ Kœnigi, Sow. Chiefly R.
„ convolutus, Quenst. Sc. Gr.
„ like Bakeriæ of D'Orb., not Sow. Sc.
„ Arduennensis, O'Orb. Sc.
„ athleta, Phil. Sc.
„ (?) perarmatus, Sow. Sc.
„ Duncani, Sow. Sc. Gr.
„ Jason, Rein. (Gulielmi, Sow.). Sc. Gr.
„ Mariæ, D'Orb. Gr.
„ Lamberti, Sow. (flexicostatus, Phil., longævus, Bean.)
„ Chamusseti, D'Orb. R.
„ lunula, Rein. Sc., rarely R.
„ hecticus, Rein.
„ putealis, Leck. Gr.
„ bipartitus, D'Orb. Gr.
„ crenatus, Brug. Gr.
Natica punctura, L. & M.
Cerithium Culleni, Leck.
Alaria bispinosa, Phil.
„ sp. (fine).
Pleurotomaria depressa, Phil.
„ guttata, Phil. (very fine).
„ granulata, Sow.
Dentalium entaloideum, Desh.
Ostrea flabelloides, Lam.
Gryphæa dilatata, Sow.
„ bilobata, Sow.
Placunopsis inæqualis, Phil.
Pecten demissus, Phil. } not frequent.
„ fibrosus, Sow. } not frequent.
„ lens, Sow. } not frequent.
Lima Phillipsii (?), large, finely-marked.
„ sp. n.
Lima duplicata, Sow.
Avicula Braamburiensis, Phil.
„ inæquivalvis, Sow.
Gervillia aviculoides, Sow. Sc.
„ small (?) acuta, Sow. R.
Pinna mitis, Phil. (?) cuneata, Bean.
Modiola bipartita, Sow.
„ cuneata, Sow.
„ pulchra, Phil. Sc.
Cucullæa clathrata, Leck.
„ corallina (?) Dam.
Nucula variabilis, Sow.
Trigonia Rupellensis, D'Orb. Chiefly Sc.
„ paucicosta, Lyc. Chiefly R.
„ *costate species.*
Cardium cognatum, Phil.
„ Crawfordii, Leck.
„ large sp. cast.
Lucina lirata, Phil.
„ crassa, Sow.
„ Beanii (?)
Corbicella ovalis, Phil.
Unicardium sp.
Tancredia curtansata, Phil. R. Sc.
Isocardia minima, Sow.
„ sp.
Anatina undulata, Sow.
„ versicostata, Buvig.
Pholadomya acuticosta, Sow.
„ Murchisoni, Sow.
Myopsis, sp.
Goniomya literata, Sow.
Myacites recurvus, Phil.
„ decussatus, Bean.
„ modicus, Bean.
„ calceiformis, Phil.
Gresslya peregrina, Phil.
Solemya Woodwardiana, Leck.
Waldheimia ornithocephala (W. umbonella ? Lam.)
Rhynchonella socialis, Phil.
Glyphæa sp.
Strophodus.
Wood, fruits, and fern-fronds.

NOTES ON THE LIST OF FOSSILS.

CEPHALOPODA.—It is somewhat surprising, after scarcely seeing a belemnite in any Oolitic bed on this coast above the horizon of the Scarborough Limestone, to find such an extraordinary quantity of that very well marked and characteristic Oxfordian form *B, Owenii,* Pratt (*B. tornatilis*, Phil.) It is long, narrow, and sub-cylindrical, like a pipe, in fact, which tapers very suddenly at one end. Professor Phillips* considered the specimens from Yorkshire less compressed than the typical form, more cylindrical, and possibly to be regarded as distinct specifically. Another striking feature of the Kelloway Rock of Yorkshire is the extraordinary abundance and variety of its ammonites. When we bear in mind that only one species is found in the underlying Cornbrash, and yet that upwards of thirty species have been enumerated and described from these beds, the marvel is from what quarter they all came. No wonder that the older geologists were disposed to believe in successive creations; for none of these species, with the doubtful exception of a variety of *A. Herveyi*, Sow. (*A. macrocephalus*, Schlot.), was ever seen in any lower beds in this country. It must be described as a regular invasion, and nothing less. Most probably this great sandbank was deposited during a subsidence of this region, far more continuous in time and extended in space than those more partial depressions which, during the period of the Lower Oolites, had, in this region, intercalated the spoils of the sea with those of the estuary and marsh. This more continuous descent seems at length to have removed or lowered barriers which had hitherto kept out the waters of a sea swarming with strange Cephalopoda. The modern system of nomenclature is curtailing the number of species, by grouping or lumping varieties; still Mr. Etheridge, as quoted by Lyell,† assigns twenty species of Cephalopoda to the Kelloway Rock of England, eight of which are common to it and to the Oxford Clay. The very great variety of forms noted from the Kelloway Rock of the Yorkshire coast is extremely puzzling, but certain groups present themselves; amongst these may be noted the group of which *A. convolutus*—rather a general sort of name—may be taken as the representative. This includes the *A. alligatus*, of Bean, and other named forms, which perhaps are only sports of this great group of *biplex* or *plicatiloid* ammonites having themselves numerous representatives also in higher beds. *A. binatus* or *A. Bakeriæ* is an allied form, and perhaps, also, the forms referred to *A. Kœnigi* have some relationship. These latter differ somewhat from what is usually understood as *A. Kœnigi* in the Oxford Clay of southern England, being usually more compressed, but are very like the figures given in the "Mineral Conchology" (Plate 263), two of the specimens being from Kelloway itself.

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* Pal. Soc., Vol. for 1869, "British Belemnites," page. 121.

† "Elements of Geology," 6th edition, p. 398.

In such forms as *A. Arduennensis* and *A. athleta* we have a connecting link between the convolute ammonites and the bolder forms of tuberculated ammonites, of which *A. perarmatus* is the culmination. *A. athleta*, Phil., is characteristically figured in "The Geology of Yorkshire." D'Orbigny* gives a capital account of this species, and of its changes of form. First there is a little rounded whorl, with extremely fine, and occasionally biplex ribs. In this stage it might be taken for any of the varieties of the Convolutus group. About the fourth whorl these fine ribs grow wider apart, and begin to stand out more prominently. Finally, when the whorls are becoming decidedly larger, the ribs are very few in number, but monstrously tuberculated. The dorsal tubercles, taken as a pair on either side of the back, present an appearance like a series of anvils. Its allies in the higher beds are to be sought in the group of which *A. Eugenii*, Raspail, and *A. Williamsoni*, Phil., are types, or rather recognised forms of an infinitely varied group, which belong to the genus *Perisphinctes* of Waagen, and have this feature in common—that the whorl is *biplex-convolute* in early life, but becomes angular and tuberculated in the adult.

The Ornatus group here presents two well-marked divisions. To one division, which has itself many varieties, the name given by Sowerby, *A. Gulielmi*, is usually applied. These specimens, preserved as they are in the spathic rock of the Castle Hill and North Shore, are very beautiful objects, and occasionally attain a considerable size. There is much variation in the mode of growth, but usually the outer whorl has a tendency to include the inner ones to a great extent, increasing somewhat in thickness also as well as in depth, the result being a steeply bevelled interior edge. The ornamentation is, however, very remarkable. The usual characters are that, starting from the steeply bevelled umbilical margin of the rapidly increasing whorl, we find a number of short, stoutish radii, which are usually twice tuberculated, a strong characteristic of the ornati. At the second tuberculation these umbilical radii are met by, and also themselves pass into, a number of very delicate radii or striæ, which cross over the flank of the shell, and are sometimes gathered by pairs into a slight knot on the squarish back. These nodes, as well as the tubercles previously mentioned, probably supported spines. If such an ammonite were flattened and preserved in clay with the terminations complete, we should recognise one of the finer varieties of *A. Jason*, Reinecke.

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* "Paléontologie Francaise, Terrain Jurassique," Vol. i., page 457 *et seq.*

The second division of the Ornatus group includes bolder and more variable forms. They are generally referred to *A. Duncani* of Sowerby, and include a variety—here pretty common—called *A. gemmatus*, by Phillips.[*] This is a highly ornamented shell, often well preserved in spathic rock. When flattened and preserved in clay, as mentioned in the previous case, we should have forms such as the *A. Elizabethæ* of Pratt. *A. spinosus* is another name given by Sowerby to one of the conditions of this species. The *A. Castor* and the *A. Pollux* of Reinecke, very fairly indicate the finer and bolder varieties. It is figured in Lyell's "Elements of Geology," p. 397, as *A. Jason*, Reinecke. A reference to the original figure of that author will at once prove that the two species can scarcely be identical. Associated with these is another beautiful group of small ammonites—viz., *Ammonites lunula*, Rein., and *A. hecticus*, Rein. They seem to run into each other considerably; at least, the specimens hitherto obtained by me do so. In the form which I take to be most like *A. lunula*, the outer portion of the last whorl is ornamented with crescent-shaped ribs, thick, but not prominent, and curving backwards like little half moons. The interior portion of the last whorl has about one-third the number of stout, elongated nodes, set in an opposite direction, so as to form an angle with the half-moons. These shells are not very common, but they form a handsome ornament to the cabinet, and are prized accordingly.

The next great group are the Cordati, which are especially numerous at Gristhorpe. The *A. Mariæ*, of D'Orb. (*A. vertumnus*, Leck.) is, perhaps, a sort of connecting link between *A. modiolaris* and the cordati, which, in mature age, may have received other names; whilst the more compressed and typical cordati are represented by *A. Lamberti*, Sow., including the *A. flexicostatus*, of Phillips, which is, perhaps, the *A. flexuosus-costatus*, of Quenstedt.—This seems to have been the immediate ancestor of the more typical *A. cordatus*, which occurs higher up. These forms are numerous in the bottom bed of "Oxford Clay" of Scarborough Castle Hill, which bed presents many analogies, as regards its Cephalopoda, with the Kelloway Rock of Gristhorpe, *i.e.*, with the peculiar bed now concealed by the landslip, from which most of the fossils marked "Gristhorpe" have been obtained.

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[*] "Geology of Yorkshire," Vol. i., Pl. vi., Fig. 17.

Gasteropoda.—The formation is not rich in Univalves, but there are a few—such as *Natica punctura, Alaria bispinosa, Dentalium entaloideum*—common to other Oolitic formations; whilst two very handsome species—an *Alaria* undescribed, and *Pleurotomaria guttata*, Phil. do not seem to have been recorded from elsewhere. Mr. Leckenby enumerates sixteen species in all.

Of Lamellibranchiata species and individuals are plentiful. A very characteristic form, common in the upper beds, is a small, round variety of *Gryphæa dilatatà*, Sow.; along with this occurs a thumbed variety, corresponding to the *Gryphæa bilobata*, Sow., stated to occur in the Kelloway Rock of Wiltshire. The species of *Pecten* are those common to nearly all the Oolites of this district. *Lima* is not abundant, but the quantity of *Avicula* is very considerable, the bulk of the specimens having a resemblance to the species called *A. Braamburiensis*, Phil. Indeed, *Aviculo, Modiola, Trigonia, Cardium*, and *Myacites*, with, perhaps, *Lucina*, are the prevailing genera. On the other hand, Crinoidea and Echinodermata are scarce, and usually, when found, in a fragmentary condition. The *Trigoniæ* are very fine, and rather special to the lower parts of the formation. Of the Costatæ, which are rare, *T. elongata*, Sow., is said to occur, as also *T. pullus*, Sow. But there are two species which occur below the Cephalopoda Zone, and which have been found in considerable quantities of late years, the former at Scarborough, and the latter at Cayton Bay, viz., *T. Rupellensis*, D'Orb., and *T. paucicosta*, Lyc. Mr. Leckenby had previously * noted *T. Rupellensis* as a variety of *T. clavellata*, Sow., much less produced posteriorly, and with the tubercles crowded on the anterior margin. Dr. Lycett has taken one of the names from the Prodrome of D'Orbigny, and applied it to this shell. It is occasionally found with both valves, which looks as if it had inhabited the bed in which it is now buried. The species is subject to much variation; it does not seem to have been met with elsewhere in

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* Quart. Journ. Geol. Soc., Vol. xv., p. 8.

England; and this remark is applicable to many forms of *Trigonia* described as species from the Yorkshire Oolites. It would almost seem as if each sandy estuary had had its own peculiar trigonia, and yet that this was constantly varying. Most of these forms have representatives in the South of England, though hardly any are exactly the same.

But if there is some difficulty in arranging the clavellate Trigoniæ what shall we say to the extraordinary variety presented by a group of smaller shells, which Dr. Lycett has described and figured under the name of *T. paucicosta*? They belong to the division of which *T. angulata*, Sow., is, to a certain extent, the type. It is only when specimens are found in an unusually fine state of preservation that any account can be taken of the sum of those minute and ever varying differences, which are held to separate species.

Brachiopoda are not very numerous, though in the upper beds *Rhynchonella socialis*, Phil., is plentiful enough.

The Oxford Clay.—The series of grey clays and shales, frequently rather sandy, which overlie the last-mentioned formation, is just as poor in fossil remains as the Kelloway Rock is rich. This poverty is of two kinds: first, a comparatively barren series of beds, and secondly, a meanness of preservation, which render forms difficult of identification, and thus unattractive to the collector. Hence both public and private collections from the Oxford Clay of Yorkshire are extremely unsatisfactory, both as to numbers, condition, and locality. The usual thickness on the coast is from 140 to 160ft. Bewicke* considers that in Newtondale the thickness of the "Blue-grey shale," including three calcareous bands, or beds of stone, is from 120 to 150 feet. Perhaps the best place for estimating its total thickness thereabouts is in the Hole of Horcum, a most curious *cirque* or *cul de sac*, which has a cap of Lower Calcareous Grit, and a floor of Kelloway Rock; the remainder of the cirque consists of the Blue-grey shales, with occasional calcareous bands. At Ampleforth, as previously mentioned, the Oxford Clay is well developed. About two years ago an extensive landslip took place on the brow east of the Roman Catholic College, and disclosed a great thickness of black paper-shales, containing flattened impressions of *A. vertebralis*, Sow., precisely that variety of the Cordatus family, which is obtained so frequently in doggers out of the inferior beds of the Lower Calcareous Grit of Cayton Bay. This makes me think it not improbable that the inferior beds of the Lower Calcareous Grit are occasionally replaced by shales, and *vice versa.* If this fact was fully established it might explain much of the stratigraphy of the Middle Oolites of the Howardian Hills. To such an extent does this clay at Ampleforth resemble, in external appearance, the jet-rock of the Upper Lias, that a considerable sum of money has been spent in drifting into the hill side with the hope of finding that increasingly scarce commodity. The Oxford Clay is to be found in the Howardian Hills in a variety of places, but so broken up by faults is this region that its position is not always clear. A rough illustration (Fig. 10) of a presumed fault at Hovingham Spa, where the Coralline beds are brought down against the Blue-clay, is here given.

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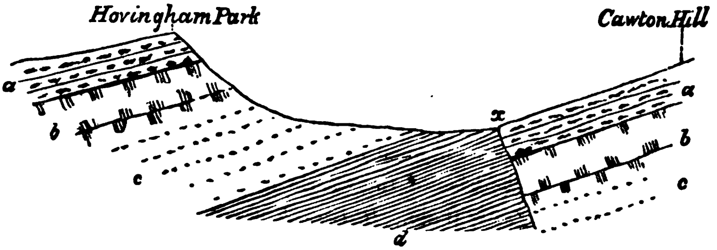
* "Geological Treatise on Cleveland," page 78.

PRESUMED FAULT AT HOVINGHAM SPA.

Fig. 10.



a. Coral Rag. *b.* Coralline Oolite. *c.* Lower Calcareous Grit. *d.* Oxford Clay. *x.* Fault.

About four-and-a-half miles, S.E., from Hovingham Park is the centre of the great lake at Castle Howard, resting most probably on Oxford Clay. Between these two points it would not be very easy to estimate the thickness of the Oxford Clay; but it is not unlikely that hereabouts sandy beds are, to a certain extent, replacing argillaceous ones. Three miles further to the S.E., we arrive at Hutton Banks, where there is about a mile of escarpment capped by Lower Calcareous Grit, which quite reminds one of the Tabular Range with a modified Nab, where the Derwent valley, in rounding the corner, describes a curve of fully 90°. There is perhaps 70 feet of Oxford Clay here, including some hard calcareous bands. The York and Scarborough Railway, by slicing off a piece of the angle, displays a good section of the upper beds, rather a rarity in this part of the interior.

There is very little noticeable in the petrology or composition of the Oxford Clay. The calcareous and pyritous nodules, so characteristic of the Lias, and of the "Speeton Clay" are not common; this may be the result of a paucity of animal remains, and certainly it is a poor formation, breaking up into cold unfertile clays, generally distinguished by an exuberant growth of rushes. Pyritized casts do certainly occur in it both along the coast and in the interior; still few can boast of many prizes from a formation which, in some places, constitutes one half the thickness of the Middle Oolites. If these immense slopes and amphitheatres of "Blue-grey shale," which are such characteristic features of the Castle Hill, of Cayton Bay, and of Gristhorpe Cliffs, could be made transparent, the relations between the fauna of the Kelloway Rock and of the Lower Calcareous Grit might be deduced more satisfactorily. It would be interesting, for instance, to determine with accuracy where the Ornatus ammonites stop, as this zone is held by some to be the top of the Middle Jura in N.W. Germany. Most of the fossils found in this formation at Scarborough occur a few feet only above the Kelloway Rock. The following species were obtained from a somewhat marly clay with Oolitic grains at the base of the Castle Rock:—

Belemnites hastatus, Blain., *B. Owenii*, Pratt., *Ammonites Lamberti* (?) Sow., *A. Cordatus*, Sow., *A. vertebralis*, Sow., *A. Mariæ*, D'Orb., Sp. allied to *A. lunula*, Rein., *A. crenatus*, Brug., *A. biplex-convolutus.*, *Gryphæa dilatata*, Sow., *Pecten vagans*, Sow. (small), *P. demissus*, Phil. (small), Hinnites sp., *Avicula inæquivalvis*, Sow., *A. clathrata* (?) Leck., *Pinna mitis* (?) Phil., *Modiola bipartita*, Sow., *Cucullæa* near to *pectinata*, Phil., *Cardium*, sp., *Astarte carinata*, Phil., *Pholadomya simplex*, Phil., *Myacites recurvus*, Phil., *Myacites*, sp., *Terebratula*, small ovate species, and *Rhynchonella socialis*, Phil. Of ammonites found as above, the Cordatus group is by far the most plentiful, and very much like the forms which occur in the Lower Calcareous Grit—more so, perhaps, than those from the Kelloway Rock. *Modiola bipartita* is, also, very characteristic of the Lower Calcareous Grit, though occurring likewise in the Kelloway Rock; but the presence of the same long, narrow form of Belemnite (*B. Owenii*) strongly connects this with the underlying deposit. As before stated, there are reasons for connecting this bed at the foot of the Castle Hill, although referred to the "Oxford Clay," with the peculiar deposit occurring at the top of the "Kelloway Rock," which is at present concealed by the landslip at Cunstone Nab (Gristhorpe).

Taking the fossils of the Oxford Clay of Yorkshire, as seen in various museums, we may observe generally great numbers of cordate ammonites. In *A. intermedius* we have an involute, shapeless mass, with a sharpish back, the outer whorl increasing in thickness towards the umbilicus, which is very deep and perpendicular. This looks rather like *A. excavatus*, one of the adult forms of the Cordatus group. There are several specimens of a very small and peculiar biplex ammonite, which I believe to be the young form of *A. Eugenii* of Raspail; and in the Cambridge Museum there is a fine specimen of *A. perarmatus*, Sow., which we should hardly look for so low down as the Oxford Clay.

FOSSILS OF THE OXFORD CLAY OF YORKSHIRE.*

	Observations.
Belemnites hastatus, Blain.	numerous.
„ Owenii, Pratt.	stout form, common low down.
„ abbreviatus, Mill.	rare.
Ammonites convolutus, Quenst.	frequent.
„ athleta, Phil.	rare.
„ Eugenii, Rasp.	York Mus.
„ perarmatus, Sow.	rare.
„ Lamberti, Sow.	low down.
„ cordatus, Sow.	very common.
„ vertebralis, Sow.	
„ Mariæ, D'Orb.	common.
„ hecticus or lunula, Rein.	
„ oculatus, Phil.	York Mus.
„ crenatus, Brug.	
Alaria, sp.	
Littorina, or Turbo, muricated species.	Camb. Mus.
Pleurotomaria, near to granulata, Sow.	York Mus.
„ depressa, Phil.	York Mus.
Turrited univalve with three whorls.	York Mus.
Gryphæa dilatata, Sow.	
Pecten vagans, Sow. *(sub-fibrosus) ?)*	

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* Not intended to be an exhaustive list.

	Observations.
Pecten demissus, Phil.	very small.
„ inæquicostatus ? Phil.	York Mus.
„ articulatus ? Schlot.	York Mus.
Lima argillacea ? Lyc.	York Mus.
Avicula inæquivalvis, Sow.	plentiful and fine.
„ species.	
Pinna mitis, Phil.	
Inoceramus ?	
Modiola bipartita, Sow.	very common.
Cucullæa near to pectinata, Phil.	
Nucula elliptica, Phil.	York Mus.
Trigonia *(costate species)*.	
Cardium, sp.	
Astarte carinata, Phil.	plentiful.
"Corbis ovalis"	York Mus.
Pholadomya simplex, Phil.	
„ decussated, sp.	York Mus.
Myacites recurva, Phil.	
„ sp.	
Goniomya, very inæquilateral.	York Mus.
Panopæa ?	York Mus.
Rhynchonella socialis, Phil.	
Waldheima impressa, Von Buch.	York Mus.
Crinoidal columns, &c.	

Assuming the general thickness of the Oxford Clay upon the coast to be about 140 feet, it may be said that if little is known of its organic contents, still less is known of their vertical distribution, beyond the fact that the upper beds have the reputation of being very unfossiliferous. There appears to have been a tolerably rapid accumulation of mud within the area, becoming more sandy as we ascend in the series ; and this condition of affairs is usually accompanied by a poverty of fossils. For purposes of comparison with N.W. Germany—if it may be deemed proved from negative evidence that the ornati do not occur higher than the top of the Kelloway Rock—we must look upon this great thickness of beds as belonging quite as much to the Upper as to the Middle Jura of that country. The prevalence of the Cordatus family at the base of this Oxford Clay on the Yorkshire Coast serves to connect it with the overlying Lower Calcareous Grit through 200 feet of beds, as does the *A. hecticus-lunula* group. On the other hand, the belemnites seem to disconnect it; for we find *B. Owenii* plentiful in the lower part of the Oxford Clay of the Castle Hill, whilst in the Lower Calcareous Grit the stout dagger-like form called *B. excentralis*, by Young and Bird, and *B. abbreviatus*, by Miller, is the most frequent species. Notwithstanding the thickness of the intervening mass, there seems to be, on the whole, a considerable palæontological connection between beds so far separated vertically, as the base of the argillaceous series in the Castle Hill, and those of the lower part of the Lower Calcareous Grit of Cayton Bay. And here the question naturally arises: do the beds called Kelloway Rock, Oxford Clay, and Lower Calcareous Grit (lower part) represent the same value in geological time with reference to each other at every point throughout the seven miles of coast? It is certainly curious how very local some fossils are; but this, of course, may be the result of accidental distribution in neighbouring beds which were absolutely synchronous.

LOWER CALCAREOUS GRIT.—As previously stated, the subdivisions are of a petrological character. They are, indeed, the natural divisions most obvious to the eye, both in section and across country; and none more so than the Lower Calcareous Grit, though it merges into, and, perhaps also in some parts, almost replaces the Oxford Clay below; whilst in its upper portions it so alternates with impure limestones and shelly beds, that it becomes a question, again only to be determined by conditions of a petrological nature, where this formation may be said to end, and the Coralline Oolite to commence. As the Lower Calcareous Grit frequently constitutes escarpments comparatively bare of vegetation, it forms a conspicuous feature in the ranges of the interior, and in the little glens which are cut through them by the numerous moorland streams. It frequently occupies the summits of the Tabular Range, which owes its peculiar configuration in a great measure to these beds. This formation acquires very extensive vertical proportions in the western escarpment of the Hambleton Hills, which terminate the Tabular Chain in that direction. Whitestone Cliff and Roulston Scar, which dominate the central vale of Yorkshire, and form conspicuous objects, as seen from the eastern slopes of the Penine Range, exhibit a vertical face upwards of an hundred feet in height, at an elevation of 1000 feet above the level of the sea, composed entirely of the lower subdivision of this formation. This latter is immediately succeeded on the dip slope to the eastwards by an oolite, which, in some places, is 40 feet thick, at least, and has no exact representative on the coast. This, again, is succeeded by a great thickness of calcareous grits, sometimes in the condition of loose sand, before we reach the real Coralline Oolite of the Vale of Pickering. The two calcareous grits, with the intervening oolite, curve round at the back of Helmsley, and appear in force throughout the greater portion of the Tabular Range. In the Howardian Hills the Lower Calcareous Grit is also of frequent occurrence, and occupies considerable tracts of country. But this system is so broken by faults and sudden tiltings of the strata that the tabular form, with its accompanying nabs, very seldom occurs; the tables being more or less upset, as it were.* Taken altogether, the Lower Calcareous Grit occupies more ground in Yorkshire than any other member of the series between the Lower Oolites and the Kimmeridge Clay.

MINERAL COMPOSITION.—There are some curious features in the composition of the rock. It may be said to commence wherever the hardening masses of the Oxford Clay become sufficiently indurated to project in the cliff as a tabular sheet. This line will, no doubt, vary according to circumstances, but along the coast may be deemed tolerably uniform. Although there is in some places a certain degree of shading off, as at Scarborough, the petrological contrast is usually very marked. Without dwelling too much upon varieties, it may be said that this lower part of the Lower Calcareous Grit is not altogether unlike a fine-grained sponge-cake. In colour it is pale-yellow or buff, of low specific gravity, and is, where exposed, almost devoid of calcareous matter; except where preserved in doggers the shells occur only as casts. This description applies with more or less exactness to many of the freestones, or building stones, with especial reference to the quarries at Oliver's Mount, Brows Quarry near Malton, Birdsall, and the Park Quarry at Castle Howard. For purposes of special description a specimen is selected from the latter quarry, containing half the aptychus of an ammonite. This fragment is useful as showing the tendency of portions of the Lower Calcareous Grit to run into chert; it appears to exhibit a sort of structure—not necessarily organic, however—and represents an extreme phase of the peculiar characteristics of this subdivision. It is almost entirely devoid of calcic carbonate, and consists chiefly of a poriferous mass of siliceous matter, which includes a quantity of extremely fine quartzose sand. The cherty portion exhibits the pores also, but there they seem further apart and less connected. Sometimes the pores are empty - pinhole structure; sometimes they contain a white powder, which is either silica or a silicate—speckled structure. In a greater or less degree the above characters may be recognised in very much of these yellow sponge-cake calc grits, giving rise to the idea of the decomposition of granular bodies of almost microscopic minuteness, which during the formation of the rock had formed no inconsiderable portion of its mass, but which, subsequent to consolidation, have, in most cases, been removed by solution. There is so much that is peculiar about calc grit—which is neither a sandstone nor a limestone, nor yet an ordinary mixture of the two, that it is almost impossible, within the limits of a general paper, to do justice to this part of the subject. Briefly, then, it is clear that, in some way or other, calc grit is connected with oolitic structure, and with coral beds, as it both precedes and succeeds this class of rock. It also alternates with oolitic beds to a great extent in the formation now under consideration; and these oolitic beds are often very sandy, and, as a rule, the granules or ova are smaller than in those of the Coralline Oolite proper, or of the Coral Rag when oolitic structure is developed in that rock. It is impossible not to believe, as regards the Lower Calcareous Grit, that some calcareous beds, with more or less of oolitic structure, were being deposited in one area whilst more gritty beds were being deposited in another simultaneously; indeed, we may feel sure, as regards the entire formation, that one thing was going on at one place, and another thing at another. Oolitic granules would, therefore, be conveyed by currents like so much sand; and the further they were carried the smaller they would become, till many of them would be no bigger than pins' heads. Multitudes of such bodies would be sealed up with the grits in the banks that were in process of formation, together with other calcareous matter. In the course of geological time many changes, due to substitution and removal, have greatly modified such porous beds as these. Solutions of silica and of calcic carbonate, under the influence of various natural re-agents, have been perpetually traversing these beds, which seem also to have been freely percolated by acidulous waters. That which may have once been the minutest of oolitic granules, transported far away from the reef to which it owed its origin, is soon dissolved, and its place is empty, or filled with a more abiding substance, and thus the pinholes and specks of calc grit may have in part arisen. Part may also be due to Foraminifera; but of this I have at present no actual proof. It may be objected to the above hypothesis—for it is but an hypothesis—that there were no reefs formed in the Oxfordian Sea at the period when the lower portions of the Lower Calcareous Grit were being deposited, and from which oolitic granules could be derived. In answer to this it may be stated, firstly, that, as a rule, especially observable at Scarborough Castle Hill, the sponge-cake rock is not seen in the very lowest beds (see Fig. 12), but is most abundant usually in the great spongy and cherty series which constitutes the mass of the formation; and, secondly, that strips of fringing reef may well have existed nearer in towards the shore, which is presumed to have been not far from the Penine Range, and which would have sufficed to supply the granules, though for reasons before stated* all traces of such reefs themselves may have been removed. Except on some such hypothesis, it is difficult to account for the thick series of the Hambleton Oolite in the very middle of the Lower Calcareous Grit.

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* See Section, Fig. 10, page 379.

Sorby† noticed a peculiar structure in some of the calc grit of Yorkshire; his specimens were taken from "just below the Coralline Oolite," and consisted of a number of agatized reniform bodies suggesting the idea of Foraminifera.

An example of one of the hard, heavy, blue-hearted bands is exhibited by way of comparison with the yellow freestone. In this case a portion of the yellow sponge-cake rock, poor in lime, is seen to adhere to the heavy blue-stone. The pore, or pinhole structure, is very manifest in the yellow portion, and may be traced some way into the blue, where, in all probability, it only requires differentiation to be brought out. The blue portion is largely charged with the carbonates of lime and iron; and yet there can be little doubt that the exterior yellow portion was once pretty nearly the same as the blue, and only assumed its present condition under a slow process of internal weathering. This is the case with a considerable proportion of the freestones of the Lower Calcareous Grit; for a bed of freestone, or sponge-cake rock, when followed for some distance into a hill side—as at Pickering—gradually assumes the hard, blue, calcareous condition. There is, however, plenty of calc grit which shows none of the above structure.

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* See page 370 on the former prolongation of the beds beyond the outcrop.

† Quart. Journ. Geol. Soc., Vol. vi., p. 1. *et seq.*

There can be no doubt that this remarkable formation constitutes the base of the Corallian series, and represents, though imperfectly, the commencement of the White Jura of the Continent. At the same time the fauna of its lower portion has considerable affinity with that of the underlying "Oxford Clay," as far as this is known. Unfortunately, the "Oxford Clay" of Yorkshire is a sort of *terra incognita* between the Ornatus-zone, as represented by the upper part of the Kelloway Rock, and the zone of *A. perarmatus*, the latter ammonite being taken as the type-fossil of the Lower Calcareous Grit, though specimens have been obtained from the Oxford Clay of Yorkshire. Thus, in the arrangement of the strata in N.W. Germany, Dr. Brauns, whilst correlating the Ornatus-clays of that country with the upper part of the Kelloway Rock* of Yorkshire, distinctly identifies his "Heersummer Schicten" (*A. perarmatus*-beds) with the Lower Calcareous Grit† of Yorkshire and of Weymouth. It therefore becomes a question of some interest as to what there is in N.W. Germany to represent the thick mass of sandy clays, known as the "Oxford Clay" of Yorkshire.

Fossil Contents.—The fossils of the Lower Calcareous Grit proper, excluding the "Passage-beds," are many of them obtained from doggers picked up along the coast. Others may be procured at various freestone-quarries in the interior. Those from Pickering and from the upper part of the Filey and Scarborough sections belong to the Passage-beds, or sandy limestones, alternating, more or less, with grits which marked the passage from conditions producing calcareous grits to those which yielded the purer Coralline Oolite. Any arrangement which attempts a division between the organic remains of a series of beds which may be said to inosculate, if studied over a considerable extent of country, must necessarily be somewhat arbitrary. Moreover, it cannot be too often insisted upon that physical conditions, varying over different areas at the same period, have had more to do with determining the molluscan life of a given area than any other cause. These remarks are more applicable to the Passage-beds than to the Lower Calcareous Grit proper, which is more uniform, besides being much poorer in its organic contents than the beds which connect it with the Coralline Oolite.

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* "Mittlere Jura," page 82.

† "Obere Jura," page 30.

In the list subjoined, which is by no means exhaustive, but one drawn up with a view to give a fair idea of the general *facies* of the fauna of the Lower Calcareous Grit, many species occurring in the Passage-beds at Scarborough and Filey are included, as their fauna has a certain affinity with that of the former. Details will be given in treating of the special sections. The fauna of the Passage-beds of Pickering, on the other hand though possessing many points in common with that of the upper Passage-beds of Filey, has more affinity with that of the Coralline Oolite—a subdivision of the series which may have been forming in one place, whilst the limestones of the Lower Calcareous Grit (or Passage-beds) were forming in another.

FOSSILS OF THE LOWER CALCAREOUS GRIT.

C. common. R. rare. Localities, in which certain fossils are known to have been found, occasionally indicated.

Belemnites abbreviatus, Mill. (excentralis (?) Y. & B.)			C.
„ hastatus, Blainv.			
Nautilus hexagonus, Sow.			
Ammonites plicatilis, Sow. (convolutus, Quenst, pars).		Cayton Bay.	
„ Williamsoni, Phil.			
„ perarmatus, Sow.		Filey.	
„ Goliathus, D'Orb.	Cordati.	Cayton Bay.	C.
„ vertebralis, Sow.			
„ cordatus, Sow.			
„ canaliculatus* Munst. (hecticus-lunula, Quenst.)		Cayton Bay.	
Natica punctura, L. & M.		Cayton Bay.	
Chemnitzia, sp.			
Cerithium muricatum, Sow,		Filey, Pickering.	
Alaria bispinosa, Phil.		Filey, Pickering.	
Littorina or Turbo, muricated sp.			V. R.
Pleurotomaria reticulata, Sow.			
Dentalium entaloideum, Desh.			
Ostrea flabelloides, Lam. (diluviana, Park).		Filey.	
„ solitaria, Sow.			C.
„ large flat species		Filey.	

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* Closely allied to A. Henrici, D'Orb.

Gryphæa dilatata, Sow.	C.
„ mima, Phil.	C.
Lima, near to gibbosa, Sow.	
Pecten sub-fibrosus, D'Orb.	C.
Avicula ovalis, Phil.	Filey, Appleton.
„ expansa, Phil.	
„ sp.	Oliver's Mount.
Gervillia aviculoides, Sow.	C.
Pinna lanceolata, Sow.	C.
Modiola bipartita, Sow.	C.
Trigonia perlata, Ag.	Filey, Pickering.
„ triquetra, Von Seebach.	Filey.
„ Bronnii, Ag.	Oliver's Mount.
Lucina obliqua, Buvig.	Filey.
„ Beanii,[*] Lyc.	Filey.
Astarte extensa, Phil.	Cayton Bay.
Isocardia tenera, Sow. (tumida, Phil.)	Cayton Bay. C.
Thracia incerta, Thurmann.	Filey.
Pholadomya angustata, Sow.	Filey & Sc. C.
„ cingulata, Ag.	Cayton Bay.
„ paucicosta,[†] Röm.	
Homomya gracilis, Ag.	Scarborough. C.
Goniomya v. Scripta, Sow.	
Myacites decurtatus, Phil.	
„ recurvus, Phil.	Cayton Bay.
Gresslya peregrina, Phil.	
Terebratula Fileyensis, Walker.	R.
Waldheimia (small) sp. n.[‡]	Hackness, Filey.
„ bucculenta, Sow.	Appleton.
Rhynchonella Thurmanni, Voltz. (varians, Schlot.)	C.
„ lacunosa, Schlot.	Oliver's Mount. R.
Glyphæa rostrata, Phil.	Appleton.
„ scabrosa, Phil.	Appleton.
Vermetus concinnus, Sow.	
Holectypus depressus, Lam.	C.
Pygurus pentagonalis, Phil.	
Collyrites bicordata, Leske.	
Echinobrissus scutatus, Lam.	C.
Pseudodiadema versipora, Phil.	Filey.
Asteropecten rectus, M'Coy.	
Millericrinus echinatus, Goldf.	C.
Thamnastræa concinna, Goldf.	Hackness.

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[*] There seems to be some doubt as to the correct name of this shell, which is probably the *Astarte rotundata* of Bean, M.S., and might pass for a small variety of *A. aliena*, Phil.

[†] Includes deltoid forms of great variety.

[‡] *W. Hudlestoni*, J. F. Walker, M.S.

Rhabdophyllia Edwardsi, M'Coy.	**Hackness.**
Spongia floriceps, Phil.	
„ sp. silicified.	
Coniferous wood and fruits.	

OBSERVATIONS ON THE LIST OF FOSSILS.—One great feature of the Lower Calcareous Grit of Yorkshire is the number of enormous ammonites which it contains. Many names have at various times, and in several localities, been given to different stages of growth of this variable genus. Three principal groups are recognisable, of which *A. cordatus*, *A. perarmatus*, and *A. plicatilis* (*convolutus*) may be deemed respectively the types.

The Cordatus group is well represented in all its branches, from the base of the Oxford Clay of the Castle Hill to the top of the Lower Calcareous Grit of Filey Brigg, including the Passage-beds, *i.e.*, through upwards of 200 feet of strata, as represented on the coast. Mature ammonites of this group have gone by the names of *A. excavatus*, and *A. Sutherlandiæ* (*Goliathus ?*); yet so difficult is it to believe that the finely-marked *A. cordatus*, or even the bolder variety, *A. vertebralis*, could, even in old age, assume these obese and unornamented forms that nothing short of finding forms, which have received such names, inside the large ones would ever induce palæontologists to believe in its possibility. Throughout the series of beds there are, or seem to be, two very well-marked varieties, known on the coast as the fat one and the thin one. In the very fat one the cordate character seems almost lost. Great stony globes, weighing upwards of one hundred-weight, representing casts of this monster, have, according to Mr. Leckenby,* been picked up on the rocks about Filey Brigg.

A. perarmatus is looked upon as a type fossil of the formation. Good examples of this well-known form are not readily procurable at the present day. The best preserved specimens have generally been obtained from doggers fallen out of the cliff. Thus the limit of its occurrence is not easy to define. It certainly occurs in the Oxford Clay, but appears never to ascend into the Coralline Oolite, nor have I heard of its occurrence in the Passage-beds of Pickering. Hence, as compared with the previous group, its range is limited. The freestone quarries of the interior, when low enough down, frequently contain it; but the specimens not being preserved in concretionary masses occur only as casts, usually rather compressed. In this state specimens are somewhat different in form, and never exhibit those wonderful spikes, which may be seen to perfection in the collection at the Cambridge Museum.

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* Article in a Guide to Filey.

There is another species of ammonite, which is referred to the *A. Williamsoni* of Phillips. It appears to be rather a biplex ammonite when young, whilst in the more mature stage the ribs become stout, and moderately tuberculated. It comes pretty near to an ammonite figured by D'Orbigny, under the name of *A. Constantii* (Pl. 186), and belongs to a group, of which *A. athleta*, *A. Arduennensis*, and *A. Eugenii* are the representatives. This group seems intermediate between the armati and the plicatiloid ammonites. Though squarish and rather tuberculated in the final whorl, it belongs to the genus *Perisphinctes* of Waagen, which includes also the plicatiloid ammonites. As far as I have been able to ascertain, its principal horizon is in the lower division of the Passage-beds, adopting the coast section as the type. It certainly occurs in the "Red beds" of the Castle Hill, and, I am informed, in the lower fossiliferous zone (*B*, *d*, lower part) of the Carr Naze section (Filey Brigg). I have also found it on Seamer Moor, where the "Red beds" crop out between the Coralline Oolite and the Lower Calcareous Grit proper. There are some magnificent specimens in the Leckenby Collection at the Cambridge Museum, of which the figure in Phillips' "Geology of the Yorkshire Coast," Pl. iv., Fig. 19, gives but an imperfect idea. In the Scarborough Museum there is a specimen, about 6 in. in diameter, which shows the interior whorls to perfection. In the early stage the back is perfectly round, like *A. plicatilis* or *A. convolutus*, with very sharp ribs, which occasionally bifurcate close to the umbilical margin of the whorl. The general character is non-involute; the last whorl increases with some rapidity, but scarcely encloses any of the preceding one; it has straight single ribs, of considerable thickness, which are slightly tuberculated over the dorsal border, giving a certain tendency to angularity in section, though not quite to the extent shown in Phillips' figure.

The last of the three great groups of ammonites is *A. plicatilis* (*convolutus ?*) and its allies. This is essentially the biplex ammonite of the horizon, and, in the young stage at least, has strong affinities with certain forms found in the Kelloway Rock. *A. plicatilis* ascends much higher than *A. perarmatus*, and is well developed in the Passage-beds, especially at Pickering, where enormous examples of it occur. In certain stages of preservation it appears as the *A. triplicatus* of Sowerby. *A. impar* would seem to be the name given to it by Young and Bird. There are specimens not unlike the *A. Achilles* of D'Orbigny, and when it puts out very thick ribs in the final whorl, it may be the *A.* [illegible] of Buckland,* named from a specimen found in the Oxford Clay (?) of Hawnes, near Bedford. This peculiar thickening of the ribs in the final whorl is frequently observed in specimens from Pickering, and other places. It is more especially the "snake" both of the freestone and limestone quarries. In the latter it is always devoid of shell, and appears only as a cast: and in most cases we must admit that the state of preservation is not always what could be desired for purposes of determination. Hence there may be varieties worthy of a specific name. Much might be done towards clearing up such doubtful points as these, if greater attention had been paid in the various collections to recording the precise localities from which specimens have come. In this way, if it could be shown that particular varieties, even if the difference were ever so small, persisted over certain geological horizons, such varieties are worthy of receiving distinctive names, though the biological value of the differences may be trifling. Thus a persistent variety, if proved to be such, becomes of immense importance to the geologist as a landmark, and therefore has something more than a mere biological value. At the same time great care must be taken, in the case of ammonites, that two or three stages of life do not receive specific or even varietal names. D'Orbigny, in this instance proceeding in an opposite direction, has swept up a number of species under the heading *A. plicatilis.* Speaking, from my own experience only, of Yorkshire specimens of this group, it first appears in the cherty limestone nodules of Cayton Bay, a noted locality for Lower Calcareous Grit fossils, and very low down in the series. There seems to be really no difference between forms from this locality, which I have never seen of any size, and the *A. convolutus* of the Kelloway Rock. Elsewhere it does not seem particularly plentiful in the Lower Calcareous Grit proper, but as a fossil of immense size occurs in great abundance in the Passage-beds at Pickering. In the final whorl all biplication ceases, and a very few stout, but perfectly smooth, ribs come on. The figure in D'Orbigny. "Terrain Jurassique," Vol. i. (Atlas), Pl. 191, described Vol. i. (Text), p. 509, as *A. plicatilis*, is not unlike some of these Pickering ammonites. The common ammonite of the Coralline Oolite is decidedly some form of *A. plicatilis*; but I have seen very large specimens at Pickering and Malton high up in the Coralline Oolite, and almost bordering the Coral Rag, which have these thick ribs in the final whorl rather tuberculated, and which are more like the *A. varicostatus* than those from lower beds. But these are questions too purely palæontological for the present communication. The intricate morphology of the individual in growth, and of the race in time, can only be worked out by special attention to the subject, in combination with the utmost facilities for the examination of numerous and authenticated specimens.

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* "Bridgewater Treatise," T. 42, Fig. 7.

A very brief notice of the remainder of the fossils must suffice. It is evident that Gasteropoda are not numerous, and in the Lower Calcareous Grit proper are very scarce indeed. *Alaria bispinosa* and *Dentalium* are the forms most frequently seen by me in the lower beds. *Cerithium muricatum* is a Coralline Oolite species, which I have never seen in the Rag beds; it is particularly plentiful in a shelly bed at Pickering, but rather scarce in the Lower Calcareous Grit proper. The occurrence of *Littorina muricata*, presuming the specimen to have been correctly named, so low down is remarkable; it has never occurred to me even in the Coralline Oolite, but everyone knows it to be perhaps *the* most abundant fossil of the Coral Rag.

There are, of course, abundance of oysters, *Gryphæa dilatata*, in every variety, and quantities of the little oyster called by Phillips *Gryphæa mima*, which does not seem to differ much from the *Exogyra nana* of Sowerby; it is especially numerous on Scarborough Castle Hill. Of the other Monomyaria, *Gervillia* is by far the most abundant, especially in the Passage-beds, both upper and lower, of the coast sections, as subsequently given. Specimens attaining enormous dimensions occur at Filey, on the coast, and at Cropton, in the interior. *Modiola bipartita* is another characteristic Oxfordian species, very common in the Lower Calcareous Grit proper. Clavellate trigonias occur, though not abundantly, in the lower sub-division: but at Filey huge specimens of *T. triquetra* are met with; this fossil is evidently related to the *T. perlata* of the Pickering beds. A considerable group of the Myacidæ and Anatinidæ close the list of the Conchifera.

Brachiopoda are not very plentiful, but much more so than in the Coralline Oolite, where I scarcely ever remember to have seen a specimen.[*] By far the most common form is the *Rhynchonella*, which Mr. Walker identifies with the *R. Thurmanni* of Voltz. It is particularly abundant in the quarries of Castle Howard Park, associated with *A. perarmatus*; this is low down in the formation. We meet it again at Appleton and Birdsall, in the building-stone quarries, and on the coast it is very characteristic of part of the lower Passage-beds at Filey (Fig 13), where it occurs with *Terebratula Fileyensis*, Walker, and many other fossils. It is essentially one of the "leit-fossils" of the Lower Calcareous Grit.

Of the Echinoidea it is remarkable that the mamillated species, so numerous in, and characteristic of, the Coral Rag, scarcely enter an appearance either in the Lower Calcareous Grit or Coralline Oolite. *Pseudodiadema versipora* is certainly found in the Lower Calcareous Grit, but its occurrence is probably not frequent. The most characteristic are *Holectypus depressus*, and especially *Echinobrissus scutatus*, which latter, however, ascends into the Coral Rag, as does *Collyrites bicordata*.[†] These urchins are not very plentiful in the grit beds, but some of them, especially *E. scutatus*, abound in the more calcareous parts, though when we come to purer Coralline Oolite they seem scarcer again.

SPECIAL SECTIONS.

There are so many places where the Lower Calcareous Grit may be examined that it is no easy matter to select what may be termed representative sections. On the coast the most complete section is to be seen on Scarborough Castle Hill.

DESCRIPTION OF THE CASTLE YARD AND HILL, SCARBOROUGH.[‡]—The area of the actual Yard is stated in the Guide Books to be a little over seventeen acres. It constitutes the tabular summit of a lozenge-shaped peninsula, which is about 270 feet high at the north end, and about 190 feet at the south end. The structure of this isolated eminence is of great interest in a stratigraphical point of view. The tabular hill is cut off from the mainland by two faults, which probably meet at an angle. The triangular space, on the north-west side, at the foot of the Castle Cliff, represents a wedge-shaped mass of lower beds which comes to a point just at the top of the moat. The result is, that close to the drawbridge the Kelloway Rock is found jammed between two walls of Lower Calcareous Grit. After passing through the archway (beneath the drawbridge), and turning sharp to the right, we find the top irony beds of the Kelloway Rock still in position for a few yards; then, for a space of thirty to forty yards, there is no reliable exposure. Finally, about forty-five yards E.N.E. of the archway, we come upon a face of rock where the "Red-beds" of the Lower Calcareous Grit are found dipping N.N.E. 10°, and rather away from the fault, which, at this point, has a downthrow on the east side of perhaps 180 feet. This fault then runs out nearly due north from here to the North Steel, where an irony buttress of Kelloway Rock, exposed on the downthrow side, forms a protecting salient to which the preservation of this curious fragment of the Middle Oolites is, in a secondary sense, due; it dips S.E. by E. 5°. At the southern extremity of the lozenge there is a far larger buttress, which dips N.E. by E. as much as 10° in some places, and crops out on the west side, where it presents a little sandstone precipice about forty feet high, facing the harbour, and probably coincident with the fault which determines the S.W. side of the Castle Hill. As the dip of the two extremities of the lozenge is inwards, but also easterly, it follows that the isolated mass of the Castle Hill forms a slight synclinal with an inclination seawards. It is curious to observe how little the dip of the Lower Calcareous Grit is affected by these strong dips of the Kelloway sandstone. Equilibrium seems to have been produced at the expense of the Oxford Clay.

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[*] *Terebratula insignis*, Schub. occurs sparingly in some parts of the Coral Rag.

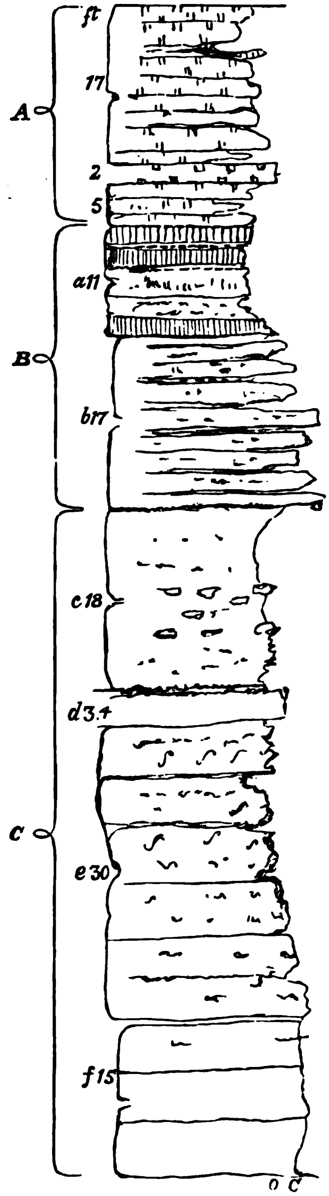
[†] *I.e.*—It is found in the fine intercoralline deposits of the *Cidaris florigemma* zone, such as occur at Hildenley.

[‡] See Fig. 11, in Plate.

GENERAL SECTION OF THE CASTLE HILL, NORTH SIDE.
(IN DESCENDING ORDER.)

		FT.	IN.
Soil, drift, and rubble		10	0
Coralline Oolite	(A)	24	0
Passage Beds	(B)	28	0
Lower Calcareous Grit proper	(C)	66	0
Oxford Clay	(D)	135	0
Kelloway Rock (top only visible)	(E)	8	0
		271	0

The Kelloway Rock and Oxford Clay of this section having already been considered, there remains the Lower Calcareous Grit, Passage Beds, and Coralline Oolite, making, as here developed, about 118 feet of beds.



EXPLANATION OF THE SECTION.

Figure 12.

	FT.	IN.
A. Coralline Oolite—		
Ova-beds above square bed	17	0
Square bed	2	0
Ova-beds below square bed ...	5	0
B. Passage Beds—		
a. Upper Division, containing the principal *Gervillia*-beds	11	0
b. Lower Division (Red beds); here the principal limestone of the Lower Calcareous Grit ...	17	0
C. Lower Calcareous Grit proper—		
c. Loose sands with doggers	18	0
d. Principal chert bed ...	3	4
e. Rough (sponge ?) Grits	30	0
f. Basement beds ...	15	0
	118	4
O. C. Oxford Clay.		

Coralline Oolite.—The upper portion of the Oolite decomposes into a sort of rubble which mixes with the drift and soil atop; but we may measure about 17 feet of white, fine-grained oolite in beds about two feet thick, parted occasionally by softer and more friable material. There are a few shells in layers, principally small *Ostrea* and *Gervillia*. The comparative rarity of Univalves is remarkable, as here we should expect to find plenty of *Chemnitzia* and *Nerinæa*, so abundant in many places about this horizon. The "square bed" is an extremely fine-grained oolite, apparently without shells; it forms a marked line in the cliff from its regularity and smooth mural surface, but otherwise is not worthy of especial notice. Below this we have five feet of white shelly limestones, slightly oolitic, and much roughened by black projections: they weather unequally, forming ledges and corridors; the lowest of these contains a line of small irony nodules. The division is not a particularly good one; but these nodules mark a line of some sort, and the beds below are, for a few feet, extremely fossiliferous. The nodules may indicate the presence of sponges of the genus *Manon ?* or *Achilleum ?* of which there are several specimens to be met with about this horizon.

PASSAGE-BEDS.—Next in descending order is the upper division of the Passage-beds (*B*, *a*, fig. 12). The two highest layers, with an intermediate brash parting, are three feet four inches thick, and contain a considerable number of fossils, of which *Gervillia aviculoides* is by far the most numerous. They may be easily reached in the angle of the cliff, just under the north battery, where they form a sort of corridor, along which it is possible to creep for a short distance. *Cylindrites elongata*, *Astarte Duboisiana*, D'Orb., *Trigonia perlata ? Sowerbya triangularis*, two species of myaciform shells, *Rhynchonella Thurmanni* (rarely), *Echinobrissus scutatus*, *Millericrinus echinatus*, *Spongia floriceps*, and the sponge doubtfully referred to *Manon*, have here been observed by me; together with the inevitable *Gryphœa mima* and *Pecten subfibrosus*, which pervade all these beds without distinction, both above and below. These shelly beds, however, are by no means constant in character; for if we trace them towards the N.E. in the direction of the Flagstaff Rock—rather a perilous proceeding—they begin to alter, and blocks of impure gritty limestones, with few fossils, are observed to take their place. The bottom shelly layer of this series, on the contrary—which, in the angle beneath the North Battery, is less rich in fossils than the two upper ones—becomes, in the direction of the Flagstaff, much more largely developed. The intervening layers (making up the total thickness of eleven feet) consist of impure gritty limestones rather false bedded. It is quite possible that an expansion of one of the gritty portions of these beds may represent a sort of equivalent to the great grit of Filey Brigg (see Fig. 13), and even of the Middle Calcareous Grit of Mr. Fox Strangways. But the thinning out of the two upper shell-beds, as previously noted, shows how local and unreliable these indications are. Such shell-beds merely represent the accidental accumulation of the remains of the fauna of the period, which the presence of a little argillaceous impurity has rather preserved from the powerful cementing action to which the purer limestones have been subjected. The same species are, for the most part, scattered throughout the adjacent rock. Hence these shell-beds can never be exactly paralleled in other localities, and all that can be expected is that we should be somewhere about the mark. The top beds of this group, merely named for the sake of distinction the Upper Passage-beds, might be referred either to the Coralline Oolite or Lower Calcareous Grit. The limestones, however, are becoming more impure as we descend.

The "Red beds" (*B*, *b*, fig. 12) consist of coarse gritty limestones, largely made up of comminuted shell and sand. They are of moderate thickness and very hard, the surface being much roughened by *Gryphœa mima*, &c. Some of the shells of the upper beds occur, but more sparingly. *Gervillia aviculoides*, for instance, often occurs throughout; but there are swarms of *Pecten subfibrosus* and *Gryphœa mima*, almost to the exclusion of more interesting forms. Indeed, Peter Cullen attributes the comparative poverty of these beds to the natural objection of other mollusca to be "growed all over with nasty little oysters." But the beds are very hard and indestructible, which is unfavourable to collecting. I have noticed, besides those fossils already mentioned, *Belemnites hastatus*, *Ammonites cordatus*, *A. vertebralis*, *A. Williamsoni*, *Lima*, near to *L. gibbosa*, Sow., *Echinobrissus scutatus*, also a peculiar variety of *Echinobrissus*, *Millericrinus echinatus*, *Ostrea solitaria*, &c. The principal zone for ammonites seems to be about the base of these Red-beds, and in the doggers of the underlying loose grit. From hereabouts *A. Williamsoni*, *A. Goliathus*, and other cordate ammonites have been obtained. Their position with regard to the underlying beds is so unmistakable that we can scarcely be wrong in correlating these "Red beds," in a general way, with those in an analogous position at Filey (*B*, *d*, Fig. 13), though there we have a richer fauna. Between Scarborough and Forge Valley they may be very fairly made out, and also at Hackness. Iron is much disseminated throughout, and shows as a reddish-yellow oxide in the softer layers, which are partially decomposed, and thus form little galleries between the hard layers. This gives a ferruginous aspect to the group. The lower portions exhibit a greater amount of this reddening, and, at the same time, contain bands and layers of intensely hard concretionary nodules, usually full of shells, which are very splintery. In a slab, at the base of this series, overhanging the soft beds which succeed, is a large specimen of *Nautilus*, which has occupied this prominent position, in spite of the elements and of the hammers of geologists, for upwards of forty years—a proof that denudation has not of late been very rapid on the surface of this cliff.

Lower Calcareous Grit Proper.—Below these last beds occur 18ft. (*C*, *c*, Fig. 12) of loose yellowish grit of medium grain, in which there are two layers of enormous doggers. Some of these contain great masses of shells, which towards the exterior of the ball occur as casts only in an adhering grit devoid of lime; whilst the interior is a mass of such intensely hard blue irony limestone that all the shells are firmly sealed up in it. *Pecten subfibrosus*, *Avicula* sp., *Gryphæa mima*, *Cardium* sp., *Dentalium entaloideum*, &c., young of a cordate ammonite, and a fruit were noticed in one. The forty inch chert-bed (*C*, *d*, Fig. 12) iso ne of those intensely hard bands which, in the interior, are often used for road stone. The upper portion weathers in a very honeycomb fashion; the interior is an impure siliceous rock, containing a little calcic carbonate, and exhibiting—especially in the lower part—the pore or pinhole structure, to which allusion has previously been made. Much silicified wood occurs in this bed. Next in descending order we have thirty feet (*C*, *e*, Fig. 12) of spongiferous (?) calcareous grit, in large blocks, rough enough to roll a Regulus upon. This subdivision may be looked upon as the backbone of the Lower Calcareous Grit proper, and the one which throughout the interior supplies most of the building stones, though not all. It contains the greater proportion of the sponge-cake rock, and the fossils usually occur as casts. The specimens from Cayton Bay are derived from fallen blocks, which belong, to the best of my knowledge, to what are the equivalents of the lower part of these beds, or, perhaps, of the upper part of the next series, in descending order. At Scarborough fossils are not numerous, though *Pecten subfibrosus* and *Gryphœa mima* still muster comparatively well, as they do throughout the whole vertical section of the Lower Calcareous Grit in this place. Besides these, I have noticed *Terebratula Fileyensis*,* *Pinna* (very plentiful in the beds below), *Gervillia*, *Alaria bispinosa*, and *Pleurotomaria* sp. There is little or no lime on the exterior of the beds, which may be taken as typical Lower Calcareous Grit after long exposure to the atmosphere; colour golden-yellow to buff. The blocks contain, parallel with the bedding, ramose projections which appear like stags' horns, and also, both on the vertical and horizontal face, immense quantities of sponges (?) roughened by small adherent shells. Such blocks strew the beach at the foot of the cliff, and are certain to attract attention from the curious figures which weathering brings out into relief. These peculiarities grow fainter as we descend toward the Oxford Clay; and the formation may be said to commence with about fifteen feet (*C, f*, Fig. 12) of a meagre argillaceous sandstone, which breaks into cuboidal fragments, and shows but few inequalities in weathering.

These various portions of the Coralline Oolite and Lower Calcareous Grit are not all approachable for purposes of investigation at any one spot. Nearly the whole of the Middle Oolites, however, may be seen in one fine precipice at the North End. Here, on the Scar, forming the base of all, is the great bulging fissured platform of Kelloway Rock,† iron bound and cherty. On this is built that noble natural edifice the Castle Hill, with its first story of Blue Grey Shale, varied by slightly harder bands, forming, where not grassed, a slope of about 35°. This, of course, is the Oxford Clay. It is succeeded by a ragged precipice of buff-coloured stone, fifty to sixty feet thick, forming the second story; this, again, is relieved by some half-grassed slopes of dangerous declivity, marking the loose sands of the Lower Calcareous Grit; and the whole is surmounted by the tabular masses of the "Red beds" and of the Coralline Oolite, constituting the Signal Staff Rock, which, as seen from below, through the mists of a winter's morning, is itself no bad imitation of a castle.

FILEY BRIGG SECTION.

The Brigg itself is a reef of rocks, which projects several hundred yards into the sea, and is covered at high water: the principal rock in situ is a thick bed of calc-grit, which I have called the Filey Brigg Calcareous Grit. This is capped in some places by a thin skin of intensely hard blue rock, which belongs to the group of fossiliferous limestones (*B*, *b*, of Fig. 13), and contains enormous examples of *Gervillia aviculoides.*

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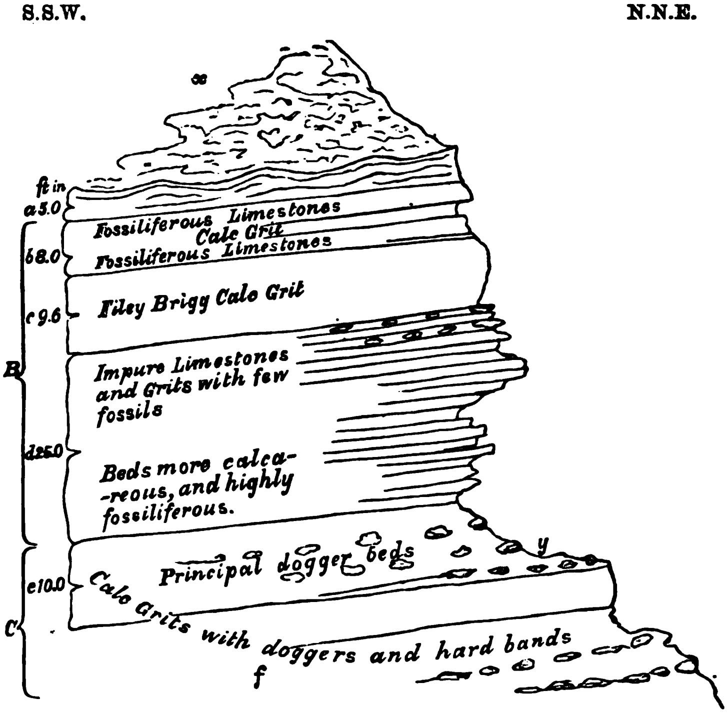
* This might almost pass for one of the shorter varieties of *T. bisuffarcinata*, Schlot.

† See Fig. 11, N.E. corner.

FIG. 13.—SECTION ACROSS PART OF THE CARR NAZE, FILEY BRIGG.



		ft.	in.
x.	Purple Drift, rising to a height of 100 ft.		
a.	Rubbly oolitic limestone, squeezed and fragmentary. ...	5	0
B, *b*.	Fossiliferous limestones, with intercalated calcareous grits —*The Upper Passage-beds.*	8	0
B, *c*.	Block Grits, generally rather deficient in calcareous matter, at least on the surface, variable, and sometimes flaggy towards the bottom.—*Filey Brigg Calcareous Grit.* ...	9	6
B, *d*.	About 18 beds of calcareous grits and gritty limestones. The upper part of the series is the most sandy, and contains at the top two bands of lenticular doggers, sometimes running into a blue and highly siliceous limestone. The lower portion contains an abundant fauna of a decidedly Lower Calcareous Grit type.—*The Lower Passage-beds*	25	0

	ft.	in.
C, e. Softish yellow calcareous grits, with hard blue lenticular concretions. Fossils similar to those in the group above *(B d)*, but less plentiful—occur chiefly in the uppermost row.—*The principal dogger or ball-bed.*	10	0
N.B.—The weathering of the softer portions of this bed forms a sort of corridor, in the lower part of which, at the point marked "*y*" in the section, is the footpath or "trod" in most frequent use.		
C, f. Upper portions of the Lower Calcareous Grit proper, which further west may be traced through a thickness of some 50ft. of beds into the Oxford Clay. The top bed is never nodular; its angular outline and mural weathering distinguish it at once; the few fossils are usually chalcedonized. Below this, as far as may be seen in the section, are calcareous grits with bands of silico-calcareous nodules occasionally becoming confluent. The shells are often chalcedonized.	n.	n.

The accompanying Section is constructed with the view of exhibiting the *general aspect*, not loaded by too many details, of the sequence of beds which may be conveniently observed at low water on the north side of the Carr Naze—to the geologist by far the most interesting part of the promontory. Some of the beds, the upper limestones for instance, can be examined from above, in those places where the slope of the superincumbent Drift (x) is not too steep. The measurements are taken for the most part between the tip of the Carr Naze, and the first cove, or "doodle," in which direction the cliff trends N.W., with a gradual rise of all the beds as far as the corner, behind which the first cove is situated. From this point to the far cove, a distance of about 500 yards, the trend is westerly; along this face we have the Filey Brigg Calcareous Grit well up in the cliff, and a large series of beds, not seen on the Brigg itself, are splendidly exposed. It is extremely probable that these measurements would vary in different places, more especially as regards the upper beds.

It will be most convenient to give a detailed description in descending order of the beds exposed in the above section, and afterwards to make some attempt at correlation with other portions of the Lower Calcareous Grit of Yorkshire.

a., 5ft.—These limestones are much shattered and squeezed, and not to be seen everywhere, on account of the sliding forwards of the Drift. They are not usually visible on that portion of the Carr Naze where the measurements were taken, but may be well observed on the south side, in Filey Bay itself, peeping from beneath the Drift. This limestone contains many small specimens of *Echinobrissus scutatus* and *Holectypus*. It probably constitutes one of the bottom beds of the Coralline Oolite, the major portion of which has been removed by denudation, if it was ever deposited in this immediate area.

B, b, 8ft. *The Upper Passage-beds.*—A few inches of brash may sometimes intervene between the rubbly oolite limestone, just described, and the uppermost limestone included in this group; but the division between the two does not seem always to be very clearly indicated. The series included in group *B, b*, consists of coarse limestones of a bluish colour, often intensely hard, and in some places rather sandy, divided by, and occasionally thinning off into yellow calcareous grits. Some of the beds consist of pale grey limestone, with buff-coloured marking and granules, the latter apparently due to ova of considerable size. Portions of these limestones, when examined closely, seem to be full of the remains of minute organisms, some being apparently sections of extremely small univalves, mixed up with oviform and irregular grains and fragments of shells, the whole being glued into a somewhat gritty mass. There are, however, portions pretty free from quartzose grit, but containing many rounded and reniform grains of opaque white silica. These are sometimes of a tolerably good size; and, on the whole, larger and more numerous in proportion to the quantity of silica than we find in the Lower Passage-beds. I have very little doubt that these are the bodies described by Sorby.* Whether they are due to the replacement of the oolitic granule by chalcedony, or to what cause, is at present uncertain; but this much is evident—that in all the beds where we have so much alternation of calcareous grits and sub-oolitic limestones, there is a great quantity of chalcedonic silica to be found, in various forms and conditions. Three limestones may, in places, be made out; of these, the third, or bottom one, is often a mere skin, resting on the great Scar-bed as previously described.

The upper limestones contain a very abundant fauna as regards individuals, if not as regards species; and, being very accessible, come in for a large share of attention. The uppermost limestone in contact with *a* (Fig. 13) contains a few Echinites, but is most remarkable for the great numbers of *Myacites*, *Gresslya*, and *Pholadomya*, forming quite a Mya bed. The *Pholadomya* is like the *Ph. angustata*,† of Sowerby. I have noticed also *Goniomya*, *Trigonia perlata* (the great *Trigonia triquetra* may, perhaps, occur here), *Lucina obliqua*, Buvig., *Lucina Beanii*, Lyc, *Lima rigida* (small, narrow variety, *subantiquata?* Rœm.), *Lima elliptica*, *Pecten subfibrosus*, *Exogyra* or *Ostrea* (small), *Pleurotomaria reticulata*, and *Chemnitzia Heddingtonensis*. *Pecten vimineus*, Sow. (? *articulatus*, Schlot.) is also found. Some of these occur in the lower limestones of the group, along with *Gervillia aviculoides*, which is generally a conspicuous fossil throughout. The intercalated calcareous grits [*] contain a few shells and fragments, are variable in thickness, and may sometimes be traced into more calcareous beds; but, on the whole, there is generally a division amounting to a foot or two in thickness dividing the limestones, as indicated in Fig. 13. The limestones on the Scar weather very rough and lumpy. Numbers of ammonites belonging to the Cordatus group are found, especially in the upper limestones; and these have rather a tendency to assume the *Goliathus* variety. Unfortunately, most of the large ammonites in the collections from Filey have been picked up loose, so that authentic testimony as to their precise position is wanting. I have seen the bed of a medium-sized plicatiloid ammonite on the south side of the Carr Naze, where this group occupies a large portion of the Scar.

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* Opp. cit., page 386.

† This name was originally given by Sowerby ("Mineral Conchology," Vol. iv., page 29, table 327) to a specimen said to have been found at Nunney near Frome *in a calcareous gritstone*. It has consequently been referred, *vide* "Morris' Catalogue," to the Inferior Oolite. Agassiz, however ("Mollusques fossiles," page 17), is disposed to confirm the species as distinct from *Ph. decemcostata*, Rœm., and tells us that he himself found the specimen, which he figures, in the Oxford Clay of Normandy.

B, c, 9ft. 6in.—A massive yellow calcareous grit, poor in lime, partly laminated towards the base. It forms the main Scar of Filey Brigg. There are a few very large shells in this bed, and amongst them a very large *Ostrea;* I have observed small specimens of *Avicula ovalis.* Possibly the great *Trigonia triquetra* may occur here.

B, d, 25ft. *the Lower Passage-beds.*—This is an important series of siliceous and sub-oolitic limestones, alternating with yellow calcareous grit; towards the base are shelly grits, and limestones extremely fossiliferous. Some of these latter are remarkable for containing a quantity of Brachiopoda, especially of *Rhynchonella*—a circumstance distinguishing them at once from the Upper Passage-beds. The higher subdivision of this series, from its abundance of grit, has, of course, affinities with the calcareous grit of the Brigg, whose deposition is foreshadowed by these beds; and we can very easily imagine their becoming so gritty, that we should be disposed to measure them in with the overlying calcareous grit. A line of lenticular nodules, which sometimes coalesce into a hard blue silico-calcareous band, is the topmost bed, and there is generally another of similar character at some little distance beneath. The first eight feet of beds are poor in fossils; still some of the common forms of the Lower Calcareous Grit are scattered about—such as *Gervillia aviculoides*, *Pecten subfibrosus*, &c.; I have found, also, *Avicula ovalis.* Below this is a line where there are several small fossils, associated with a small *Serpula*, of rather peculiar form. The lowest ten feet of beds contain a really fine series, and constitute, upon the whole, the most interesting portion of the Filey Brigg section. Some of the beds are peculiar: a specimen, highly charged with *Rhynchonella*, is a blue-centred rather gritty limestone, buff-coloured at the edges, and full of small yellowish oolitic granules, like fig seeds, well shown by contrast against the blue matrix. Sections of the stems of *Millericrinus*, in opaque calcite, impart a glistening appearance, which is further enhanced by the sparry condition of some of the rhynchonellas. One little *Pseudodiadema* may be noted. There are plenty of those curious dichotomizing forms in these beds, which throughout the Filey promontory generally are such characteristic features of the Lower Calcareous Grit. Whether these curious forms are due to sponges or not may be a question. It seems probable that they represent an organic body of prolate growth, which ramified freely in the accumulating sandy and calcareous sediment, and whose decomposition has determined the deposit of a larger amount of calcitic and siliceous matter than has been the case with the surrounding mass; weathering has brought this difference into relief. The quantity of organic and pyritous matter yet remaining unoxidised in the cores of these bodies causes them to be blue-centred when the surrounding mass has already assumed the pale buff of the ordinary calcareous grit. Very fine quartzose sand is the principal ingredient of the insoluble portions of these limestones, but there are a considerable number of small oval bodies of opaque white silica, similar to those already mentioned, as occurring in the Upper Passage-beds, where, however, they are generally larger. There is, also, a considerable quantity of opaque white silica in fragments, which seems to have replaced shelly matter.

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[*] In one of these yellow grits Mr. Blake, last summer, noted a specimen of *Ammonites perarmatus.*

Groups and scattered specimens of *Rhynchonella varians*, var. *Thurmanni* are plentiful; more rarely we find a shortish variety of *Terebratula* allied to *T. bisuffarcinata* (*T. Fileyensis*, Walker), and there is a small *Waldheimia* occurring rather plentifully upon a certain line. *Gryphæa dilatata*, *Ostrea flabelloides*, *O. solitaria*, *Gervillia aviculoides*, *Isocardia*, *Millericrinus echinatus*, *Serpula*, and nests of the inevitable *Gryphæa mima* are the most obvious fossils. About six feet from the bottom is a bed so full of *Gervillia* as to attract some notice; cordate ammonites occur throughout. *A. perarmatus* is also reported from here, as we should expect, though probably more plentiful still lower down in the series. I hear also of an ammonite which answers to the description of *A. Williamsoni;* the latter fossil is certainly characteristic of the "Red beds" of Scarborough Castle Hill (*B*, *b*, Fig. 12), which occupy an analogous place just above the Dogger-series, and are there the representatives, as regards position, of the Lower Passage-beds, though the fauna is somewhat different. Fossil wood is rather plentiful, both in this and the underlying division. These beds are finely exhibited in the curious rocky amphitheatres called "doodles," where splendid overhanging slabs of rock belonging to this series may be observed charged with the above fossils, and interwoven with the large dichotomizing branches to which allusion has already been made.

C, *c*, 10ft. *The Principal Dogger or Ball Bed.*—This is placed, as a matter of convenience, at the top of the Lower Calcareous Grit proper (*C*), though it has many connecting links with the beds above. As we descend, however, limestones are becoming scarcer, and we here find ten or twelve feet of softish yellow calcareous grits, with rows of monstrous lenticular and sub-spherical concretions, which are well brought out by weathering. There are a few of the same species of fossils in these great balls as occur in the higher beds, which themselves have a nodular tendency in places; still, on the whole, weathering draws a pretty good line between them, and this can scarcely be said to be exaggerated in the section, though it is not equally obvious everywhere. These balls are occasionally run together in a reticulated mass, as may be seen in one of the "doodles," where the interstitial sand has been washed away, and the passage from this into the continuous blue silico-calcareous rock can be easily imagined.

The peculiar configuration of the cliff or scar at the northern base of the Carr Naze is, in a great measure, due to the unequal weathering of this belt of rock, aided by dripping from above. Some of the coves contain little pools—perfect baths in miniature—of salt water, renewed every tide, which stand in hollows excavated out of the looser sands, but always supported on the hard mural band of grit beneath, on which the lowest row of doggers frequently rests. It is almost impossible to avoid speculating upon the origin of this curious formation, which is so very characteristic of the Lower Calcareous Grit, but especially of this horizon. The tendency to run into the hard continuous blue band seems, in some way, to connect the Ball-beds with that kind of rock; and the lenticular and separate character of the concretionary action may have been due to the insufficiency of the cementing material in a porous formation which has been constantly undergoing changes from chemical action. The subject, however, is far too complex to discuss thoroughly in a paper like the present.

C, f.—This is the exhaustive division which takes in all the remainder of the section visible. The top bed may be recognized by its character as shown in the section. It is an extremely hard calcareous grit, supported in places by a band which is rather cherty, though true chert is far from common. The few fossils are chalcedonized; we may note sections of chalcedonic *Gervillia*, and nests of what seem to have been *Rhynchonella*, now a mass of quartz crystals. It seems to represent the Chert-bed (*C, d*, Fig. 12) of the Castle Hill, in position certainly, if in nothing else; but is less decidedly cherty than that remarkable band. The remainder of the accessible portion of the section consists of yellow calcareous grits, with hard blue doggers, often confluent, but more siliceous than those previously described. There are some large fragments of monomyarian shells which are chalcedonized.

CORRELATION.—The section at Filey, of what may be termed, in case objection is made to the phrase "Passage Beds," the upper portion of the Lower Calcareous Grit, is so complete, that it tempts us, not indeed to constitute it a type-section—such would be a mistake in so variable a series—but to make it a standard of reference, affording us some clue to the history of the formation in other places, and especially in the interior. When we seek to parallel the several subdivisions above detailed, with others in East Yorkshire, we must, first of all, bear in mind the extreme variability of the entire series, according as the shelly drifts or the sandy drifts prevailed in any given area. Reflection on this point will at once show the utter impossibility of establishing anything more than a general accordance, due rather to approximation of physical conditions, than to absolute contemporaneity. When we consider the history of the Upper Oxfordian in the Yorkshire area, as a whole, we perceive that the argillaceous deposits, never very free from sand, gave way by degrees, and sooner in the west than in the east, to arenaceous ones, which, in their turn, became charged with an increasing amount of calcareous matter. Up to a certain point, the arenaceous matter was so considerably in excess, that the resulting beds partake more of the character of grits than of limestones. At length there arrived a time when calcareous matter began to prevail, and this point is generally to be noted as occurring above a very well-marked line of concretionary masses, similar to the dogger bed, *C e*, of Filey. It by no means follows—in fact, it is improbable—that this point was arrived at contemporaneously over the whole area, but where it does set in, we have the Passage-beds, or upper Lower Calcareous Grit, which present more variety than the lower subdivision, and might even be worthy of distinctive names, according to their respective development in the several localities where they occur. These Passage-beds represent a sort of struggle between lime and sand, which resulted in a victory for the former, when, ultimately, the purer limestones of the Coralline Oolite began to be deposited. The following attempts at correlation must, therefore, be made with the above considerations in full view, and the names used must be deemed only names of convenience, enabling us to identify certain beds.

B, b. The Upper Passage-beds.—As regards the fauna, there is no reason why the uppermost limestones should not be classed with the Coralline Oolite, but as they are still associated with beds of undoubted calcareous grit, they must, on petrological grounds, be referred to the group, which, as a whole, is called the Lower Calcareous Grit. The abundance of cordate ammonites does not prove much, but these are by no means common in the finer limestones of the Coralline Oolite. If we try to parallel these upper Passage-beds with the Scarborough Castle Hill section, they may perhaps be found to correspond pretty nearly to the two *Gervillia*-beds, in the upper part of *B. a*, Fig. 12, which there lie about the base of the Coralline Oolite, of which a much larger portion is preserved than at Filey. On a comparison of the lists of fossils, there is certainly no very great degree of resemblance, beyond the fact that *Gervillia aviculoides* is very common in both, and that *Trigonia perlata* also occurs in each. Myaciform shells, too, are pretty plentiful in the *Gervillia*-beds of Scarborough, and the number of small echinites is also a connecting link. With the *Trigonia*-beds of Pickering, there is, as regards fossils, a closer resemblance. *Gervillia aviculoides*, *Trigonia perlata*, *Lucina Beanii*, *Lima elliptica*, *Chemnitzia Heddingtonensis* being tolerably abundant in each. But there are important differences also, as, for instance, at Filey the absence or rarity of *Nerinæa*, and at Pickering the absence or rarity of echinites and of *Myacites*, *Pholadomya*, &c. As before observed, too much importance must not be attached to the presence or absence of this or that fossil. Nearly all are of species that lived throughout the entire period, and their presence or absence, when not influenced by important differences due to physical causes, is, in fact, the result of the accidents of distribution. One common feature unites all three sets of beds, viz., the rarity of brachiopods. I have found *Rhynchonella*, though very seldom, in the *Trigonia*-beds of Pickering, one specimen in the *Gervillia*-beds of Scarborough, but not yet in the Upper Passage-beds of Filey.

B, *c*. *Filey Brigg Calcareous Grit.*—This second irruption of gritty sediment is not exactly paralleled in the Scarborough Castle section, where its position would be in the lower part of *B a*, Fig. 12 ; nor do we find it making any show on the surface, or in any quarry or natural section between the coast and the gorge of the upper Derwent above Ayton. In the central and western portions of the Tabular Range, a similar deposit, in a somewhat analogous position, but enormously expanded, divides the two limestone groups, which I venture to correlate approximately with the Upper* and Lower Passage-beds. On the Wass moors, N. W. of Oswaldkirk, this occupies a large surface, where it may often be observed in the condition of loose sand, owing to the powerful action of solvents, generated by the decomposition of the peat. In this position it has evidently been mistaken for Upper Calcareous Grit, a subdivision of the Supra-Coralline beds. At Pickering an unknown thickness of calcareous grits, some very sandy indeed, underlie the *Trigonia*-beds, and may be supposed to represent, so far as such a variable series can represent, the Filey Brigg Calcareous Grit. On the other hand, in the Howardian

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* There are cases even in areas where the Second grit is developed, where the Upper Passage-beds are so merged in the base of the Coralline Oolite, as to render any distinction unnecessary.

Hills, the Second grit does not seem to occur, and the limestones of the Lower Passage-beds, where they are represented palæontologically, as at Appleton, form the base of the Coralline Oolite. In these cases, the Upper Passage-beds are not developed as such; for, in fact, they require a second grit to develope them, otherwise their fossils are more or less merged in the general mass of the Coralline Oolite, as is the case at Malton.

B, d. The Lower Passage-beds.—On referring to page 398, it will be perceived that this very important series is correlated, as regards position, with the "Red beds" of the Castle Hill section, and if we except the absence or rarity of brachiopods at Scarborough, there is considerable resemblance in the more obvious fossils of each. But the lower portion of the "Red beds" is more ferruginous than the corresponding portion of the series at Filey, and in the interior, west of Scarborough, this peculiarity is still further developed, as at Hackness, on Seamer Moor, in Forge valley, and, above all, in Beedale, beyond which valley I have not traced it in a westerly direction. In Forge valley, just above Ayton, the ferruginous beds are very clearly seen at the base of an important series of limestones, which, in varying degrees of purity, have a thickness of probably over 100 feet, without any obvious intervening grit. Here, if I understand the section rightly, we have the Lower and Upper Passage-beds, the Coralline Oolite, and the Coral Rag with *Cidaris Smithii*, but not with *Cidaris florigemma*, all in continuous sequence. The lower portions of this great limestone series, at Ayton, are, as regards position, the nearest to our Lower Passage-beds. They consist of large bedded, and comparatively unfossiliferous suboolitic limestones, sufficiently pure to be quarried for lime. A closer search would probably indicate the characteristic fauna; but these lower Oolites are generally poor in fossils, thus presenting a marked contrast to the Coralline Oolite proper. Further west in the Tabular Range, where the Second grit comes on, there is a remarkable limestone formation, often highly oolitic, immediately below it. This limestone, in some places on the Hambleton moors, attains a thickness of over 40 feet. The distance and general difference of development between Filey and Hambleton is so great, that absolute correlation is quite out of the question. The Hambleton oolites are gritty and small-grained, but pure enough to be burnt for lime, though too siliceous for smelting purposes.

Like most of these small-grained oolites, they are rather poor in fossils. Their position is somewhere on a level with these Lower Passage-beds, *i.e.* to say, they are midway between the Second grit, and the Lower Calcareous Grit proper.

In the Howardian Hills, where the Second grit does not come on, we perceive at Appleton a fauna similar to this at Filey, but packed into a much smaller space. There it lies at the base of the Coralline Oolite. Generally, it may be said of the Howardian Hills that, in the absence of the Second grit, there is a considerable thickness of sandy sub-oolitic limestones, full of little buff-coloured grains like fig-seed in a compact matrix, lying at the base of the Coralline Oolite. In this case the Second grit, and Upper Passage-beds, are absorbed in the general mass.

C, e.—As regards the principal Dogger-bed, it is not difficult to parallel it with the very similar one at Scarborough, *C c.* of Fig. 12, though it by no means follows that they are synchronous deposits. In the onward progress of the Lower Calcareous Grit, we may look upon them as representing, each in its own area, the same stage in the physical history of the formation. In the interior, owing to a want of proper exposure and differentiation, the fossil "cannon balls," are not always to be proved. A few miles west of Pickering, where the river Seven flows at the bottom of the gorge cut through the Tabular Range, between Crofton and Sinnington, there is, close to the Mill, a fine exposure of the Dogger-bed with three rows of balls. These fall out of the little cliff into the bed of the stream, where they look like a collection of lapidified cheeses—just such stones as an otter would love to sit upon.

CONCLUSION OF SECTION 1.

The deposition of the thin band of limestone called the Cornbrash marks, within a part of this area, a period in Jurassic times during which mechanical deposits were scanty. When these regained their sway, we have in the *Avicula*-shales of the coast the physical conditions of the Oxford Clay, without special Oxfordian fossils. Neither do we find these at the base of the thicker portions of the arenaceous deposit which succeeds, and is known as the Kelloway Rock. Towards the top of this there is a great quantity of fossils accumulated, as in the underlying Cornbrash, within the vertical space of a few feet. These are

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The Grey Shale, or so-called Oxford Clay of Yorkshire, even on the coast, hardly represents one half of the real Oxford Clay of Middle England, whilst in the Western escarpment it shows signs of going out altogether ; so that, if the beds were prolonged for a few miles in the direction of their outcrop towards the Penine Range, the Lower Oxfordian sandstone (Kelloway Rock) would meet the Upper Oxfordian sandstone (Lower Calcareous Grit). Thus these two arenaceous deposits are, in the Hambleton escarpment, almost the sole representatives, in time, of the Oxford Clay of other areas, an intimation that we are near the old shore line. Taking the whole of the Yorkshire area, the "Kelloway Rock," "Oxford Clay," and "Lower Calcareous Grit," replace each other to a considerable extent, and must be viewed simply as varying parts of one great formation known elsewhere as the Oxford Clay.

The Upper Oxfordian beds, being deposited in shallower water, formed the base on which a growth of coral took place ; such coral beds being situated in the first instance near the shore, where their detritus, mingled with much fine sand, formed the Lower Calcareous Grit. As the waters grew shallow at increasing distances from the shore, the proportion of calcareous sediment increased, and we have the Passage-beds ; to these succeed the various Corallian limestones, the consideration of which is worthy of a separate section.

ORDINARY MEETING, JANUARY 7TH, 1876.

HENRY WOODWARD, Esq., F.R.S., Vice-President, in the Chair.

The following Donations were announced:—

"Quarterly Journal of the Geological Society," Vol. xxviii., Part 1; from that Society.

"Abstracts of the Proceedings of the Geological Society," Nos 308 and 309; from that Society.

"Abstracts of the Proceedings of the West London Scientific Association;" from that Association.

"Journal of the Society of Arts," December, 1875; from that Society.

"Proceedings of the Royal Physical Society [of Edinburgh]," Session 1874-75; from that Society.

"Proceedings of the Somersetshire Archæological Society for 1874;" from that Society.

"Journal of Proceedings of the Winchester and Hampshire Scientific and Literary Society," Vol. ii., Part 1; from that Society.

"Annual Report of the Yorkshire Philosophical Society for 1874;" from that Society.

"Illustrations of the Geology of Yorkshire. Part 1: The Yorkshire Coast." 2nd edition. Edited by R. Etheridge, F.R.S.; from the Editor.

"On some Newly Exposed Sections of the Woolwich and Reading Beds at Reading, Berks," by Professor T. Rupert Jones; from the Author.

"On the Observation of Periodical Natural Phenomena," by John Hopkinson, F.L.S. &c.; from the Author.

"Descriptions of the Graptolites of the Arenig and Llandeilo Rocks of St. David's," by John Hopkinson and Charles Lapworth; from John Hopkinson, Esq., F.L.S., &c.

On the recommendation of the General Committee, Professor James Tennant, F.G.S., and J. T. B. Ives, Esq., F.G.S., were elected Auditors of the accounts of the Association for the year 1875.

The following were elected Members of the Association:—M. La Chaussée Bujac; Mrs. Heath; Dr. Hector, C.M.G., F.R.S., Director of the Geological Survey of New Zealand; John Holbrook, Esq.; George Payne, Esq., jun.; John Saul, Esq.; and Edward Lionel Scott, Esq.

The following Paper was read:—

ON THE GEOLOGY OF NEW ZEALAND WITH SPECIAL REFERENCE TO THE DRIFT OF THAT COUNTRY.

By Dr. HECTOR, C.M.G., F.R.S., Director of the Geological Survey of New Zealand.

(Abstract).

The author first drew attention to the geographical position of the islands, indicating on the South Polar chart their situation relative to known lands of the Antartic area. Great ice-packs encumber the intervening ocean, circulating around the pole; travelling in a spiral, and thus increasing their distance from the centre. On the meridian of South Shetland, as low as 40° S. latitude, the seas are at all seasons crowded with icebergs, but there is an indentation of the ice-pack opposite Australia and New Zealand, though erratic masses escape sometimes. There are, however, five degrees of latitude off the extreme south of New Zealand, clear of the limit where icebergs are ever found. As regards latitude the islands occupy a position equivalent, in the Northern Hemisphere, to a line between Paris and Algiers. They lie parallel to Australia, 1,200 miles E. by S., and repose on a sub-marine plateau, which, along the west shores of the islands, is submerged to a depth of from 1,200 to 1,300 feet, but further westward terminates in water 6,600 feet deep. The edge of this plateau comes close in shore on the S.W. extremity of the Southern (middle) island. Thus New Zealand is a remnant of a once far more extensive land, whose eastern boundaries are not as yet clearly defined, but the author was disposed to include the Chatham Islands as a portion of it. *North Island.*—The eastern shore is the boldest; foul weather, and consequently denudation, coming from the N.E. The west side is more shelving; but the great volcanic boss of Mount Egmont, which rises at a gentle angle to a conical summit, protrudes its protecting buttresses of lava far into the western sea, and has thus been the means of preserving a great tract of Miocene Tertiaries behind it; these constitute some of the best land in the country. *South Island.*—The denudation comes from the west: its western shores also approach nearer to the edge of the plateau, and the mountains of the south-west angle rise from a profound abyss to a height of from 4,000 to 5,000 feet. In the North Island a belt of hard rocks, consisting of the Upper Palæozoics, and the older Mesozoics, constitutes a sort of back-bone, occupying the east-central portions, against which the softer beds of more recent age recline. In the South Island this belt of Upper Palæozoic rocks, constituting the high mountain chain known as the Southern Alps, sweeps down through the centre with an incline towards the west, and then curves round towards the east again quite to the sea on that side. Against these also the Upper Mesozoics and Tertiaries recline. On the west and south of this easterly bend of the belt of the newer Palæozoics a great mass of foliated rocks occur in the province of Otago, constituting the well-known gold-field. In the far south-west we have only crystalline rocks, and these belong to a series which seems to reappear in much of the detached lands of the Southern Ocean, such as Kerguelen's Land, Auckland Islands, &c., where Miocene volcanic rocks also occur. The meteorology of the country, as having an important bearing on the denudation of the surface, was next considered. Referring principally to the Southern Island, we have here the mixing point of the N.E. and S.W. currents. On the west Oside, at kitika, the annual range of temperature is 50°; on the east side, at Christchurch, 65°; moisture, west side, 90°; east side, 75°; rainfall, west side, 120 inches; east side, 25 inches; number of rainy days, west side, 202; east side, 91. Much of this enormous precipitation is deposited as snow in the Southern Alps, which comb out the moisture from the westerly winds; hence the extensive glaciers of the mountain region and the comparative dryness of the Canterbury Plains. Mount Cook has an elevation of 14,000 feet; this is the principal snow area of the Southern Alps, and here the island is narrowest. In shape this snow-field is less compact than that of the Bernese Oberland and of the Mont Blanc region; their respective areas are: snow-field of Mount Cook, 160 square miles; Bernese Oberland, 140 square miles; Mont Blanc, 75 square miles. The crystalline mountains of the south-west do not contain nearly so much snow. The Tasman glacier is 18 miles long, and 2 miles wide at its terminal face; the terminal face of the Godley glacier is three miles across. The author then gave a description of the leading features of the glacier scenery, illustrated by very effective pictures; one of Milford Haven, with the half-snowed peaks of Mount Pembroke and its neighbours rising to a height of more than 5,000 feet, was very striking; he also demonstrated the erosive action of glaciers in cutting back cols—an action more energetic formerly, some of the cols having been worn down as low as 1,800 feet. The author pointed out on a map, specially constructed for the purpose, the immense extent of the snow area in former times as contrasted with that now existing. This is proved by the abundance of moraine matter. At present the glaciers on the west side of the Southern Alps are remarkably clean (as was well shown by a splendid series of sketches in colour by the Hon. Mr. Fox and lent for exhibition to the meeting), whilst those on the east side are largely charged with detritus. Following a given section in this direction away from the central ridges we find generally a rock basin, and still lower immense moraines extending to the Canterbury Plains, till they pass under the deposits of these plains, which are referred to Pliocene and Post-Tertiary age. In further illustration of the former extent of the snow-fields, the author indicated old centres of glaciers in the north of the island. The reason for this contraction of the ice area is the great question for determination. Was it due to difference of climate, the result of a great Glacial period? The remains of the past fauna afford no evidence of this. We may, indeed, suppose that the whole fauna migrated to the north, but we must in that case invent the land and bring into play oscillations more extensive than those required for another alternative, viz., the alteration of level within the area itself. We might suppose a general alteration of level, even to the extent of 4,000 feet higher than at present, but the evidence afforded by the shore line is unfavourable to this view. There remains then the theory of unequal elevation, which, combined with a most enormous destruction of surface, the result of ages of glacier action, best explains the phenomenon. There can be no doubt that at present the south-west portion of the island, where the crystalline rocks prevail, is very much depressed in comparison with its position at some former period; the extraordinary depth of the sub-marine valleys proves this. The author was inclined to believe in a period of irregular elevation, the south-west portion having been elevated first, though possibly the Nelson region at a still earlier date. In conclusion, the author stated his belief that there had been no general change of climate, but many changes of relative level, resulting in a great destruction of surface, which had taken place in groups of peaks at different times; the areas of the crystalline rocks have been least affected in their relative changes of level, the oscillation having been greater in other masses, which have been crumpled up against these.

ANNUAL GENERAL MEETING.

February 4th, 1876.

William Carruthers, Esq., F.R.S., F.G.S., &c., President, in the Chair.

The following Report was read by the Honorary Secretary:—

REPORT OF THE GENERAL COMMITTEE FOR THE YEAR 1875.

The General Committee, in presenting their Report, have every reason to congratulate the Members upon the results of the past year.

A large number of new Members have been elected, and the interest evoked in several localities by the Excursions of the Association, have attracted the attention of local geologists to a considerable extent.

The losses by death and withdrawals have not been very great, but your Committee have thought it necessary to exclude from the Association several Members whose contributions to the Treasury had been in arrear for a considerable time. Your Committee regret to say that in this way some of the founders of the Association have, in consequence, ceased to be Members.

Members elected during 1875 ...		... 48
Deaths	6	
Withdrawals and exclusions	30—	... 36
Increase		... 12

The Census of the Association on the 1st of January, 1876, gave the following results:—

Honorary Members	14
Life Members	46
Old Country Members	24
	84
Other Members	267
	351

In consequence of the increased punctuality in the payment of subscriptions, and the gathering in of arrears, the revenue of the Association is in a very satisfactory condition, as a reference to the balance-sheet will show, and your Committee have much pleasure in finding that Members have responded so readily to the suggestion contained in the Report of last year.

Notwithstanding the increase in the number of pages of the "Proceedings" for 1875, the expenditure of the Association has been kept within moderate limits, and a sum of £60 has been invested in Consols, being £18 in excess of the amount of Life Compositions received during the year. The amount of stock now possessed by the Association is £207 9s. 6d., which, at 94, represents a money value of about £195 0s. 11d. The number of Life Members is 46, representing composition fees to the amount of £248. If, therefore, a further sum of £48 be invested, the obligations of the Association to its Life Members will be fully discharged, and yet leave a balance in the hands of the Treasurer sufficient for all contingencies.

The General Committee have much pleasure in congratulating the Members on the amount of matter which has been published in the "Proceedings" for the year 1875. When the publication of Quarterly Proceedings was determined upon in 1871, it was intended to give about 32 pages to each number, and that matter might not be wanting for a regular periodical issue, it was resolved to commence the chronological record with the business of the meeting of February, 1870. So great, however, has been the amount of work done by the Association since that period, that the publication of merely four numbers of 32 pages each annually, would have been altogether inadequate to your requirements, and there would now have been a large accumulation of matter unprinted. The financial progress of the Association having happily kept pace with the amount of work accomplished, your Committee have been enabled to publish much more than was originally contemplated, and by larger numbers and extra numbers, the "Proceedings" have now overtaken the business. An average publication of 212 pages annually, for five years, instead of 128 as intended, shows that the Committee have not been unmindful of the desire of the Members for an early appearance of the Papers, Lectures, and Reports of Excursions, which they rejoice to know are highly valued when printed.

Papers on a great variety of subjects have been read during the year.

The President, on the opening of the session 1875-6, followed the example, so well set by his predecessor, of delivering an Inaugural Address, which attracted a large audience.

The attendance at the Evening Meetings has generally been good.

The following is a list of the Papers brought before the Association during the year 1875 :—

Notes on the Volcanic Geology of Iceland, by WILLIAM LORD WATTS, Esq.

On the Relative Age of some Valleys in the North and South of England, and of the various Glacial and Post-Glacial Deposits occurring in them, by C. E. DE RANCE, Esq., F.G.S.

Remarks upon Geological Boundary Lines, by HORACE B. WOODWARD, Esq., F.G.S.

Notes on the Probable Depths of the Gault Sea, by F. G. H. PRICE, Esq., F.G.S.

Notes on the Flora of the Gault, with a description of a New Cone, by the PRESIDENT.

On the Relationship between the Somme River and the Somme Valley, by JAMES PARKER, Esq., F.G.S.

On the Flora of the London Clay of Sheppey, by the PRESIDENT.

On the Mechanical Laws of the Movement of Rivers and Glaciers, and the Effect of these Agents in producing Valleys, Lakes, and the Contours of the Land just prior to the Historic Period, by ALFRED TYLOR, Esq., F.G.S.

On some of the Causes which have helped to shape the Land on the North Wales Border, by D. C. DAVIES, Esq., F.G.S.

The Yorkshire Oolites, Part II., by W. H. HUDLESTON, Esq., M.A., F.G.S.

Opening Address, Session 1875-6, by the PRESIDENT.

On Quartz, Chalcedony, Agate, Flint, Chert, Jasper, and other forms of Silica, geologically considered, by Professor T. RUPERT JONES, F.R.S.

During the year the following Museums and Collections were inspected :—

Museum of Practical Geology :—	
Mineralogical Collection	F. W. Rudler.
Palæontological Collection	R. Etheridge.
Leicester Town Museum	W. Harrison.
Museum of the Yorkshire Philosophical Society	W. Reed. J. F. Walker.
Whitby Museum.	
Museum of the Scarborough Philosophical Society	The President and Directors of the East Yorkshire Excursion.

The Excursions of the Association have been very well attended during the past year, and in this respect the Committee are able to congratulate the Members on the success of an institution which is peculiarly the province of the Association, and which, it is believed, not only benefits those who share in the Excursions, but also tends to promote geological enquiry in each district visited. An increase of Members followed each visit into the provinces. Your Committee are, however, aware that the shorter Excursions in the neighbourhood of the metropolis are of equal importance to a certain section of the Members, though in these the attractions of novelty are more difficult to procure. An attempt to lessen the cost of the longer Excursions should be made.

Subjoined is a list of the Excursions made during the year 1875, arranged in the order of the formations visited :—

PERIOD.	FORMATION.	LOCALITY.	DATE.
Post Tertiary.	Thames Valley Gravels.	South Kensington.	July 10.
,	Mammalian Deposits.	Crayford.	June 26.
,,	Palæolithic Gravels.	Herne Bay.	March 30.
,,	Purple Drift (Boulder Clay).	Filey Bay.	June 23.
,,	Boulder Clay.	Mount Sorrel.	May 19.
,,	Middle Glacial ?	Watford.	May 1.
Eocene.	Bagshot Sands.	Isle of Sheppey.	June 7.
,,	London Clay.	Isle of Sheppey.	June 7.
,,	Woolwich and Reading Beds, &c.	Richborough.	March 29.
,,	,,	Oldhaven Gap.	March 30.
,,	,,	Watford Heath.	May 1.
,,	,,	Erith.	June 26.
,,	Thanet Sands.	Pegwell Bay.	March 29.
,,	,,	Reculver.	March 30.
,,	,,	Croydon.	April 17.
,,	,,	Erith.	June 26.
Cretaceous.	Upper Chalk.	Isle of Thanet.	March 29 & 30.
,,	,,	Croydon, &c.	April 17.
,,	,,	Watford.	May 1.
,,	,,	Crayford.	June 26.

PERIOD.	FORMATION.	LOCALITY.	DATE.
Cretaceous.	Red Chalk.	Speeton Cliffs.	July 23.
,,	Speeton Clay (Neocomian)	,,	July 23.
Jurassic.	Kimmeridge Clay.	Filey Bay.	July 23.
,,	Upper Calcareous Grit.	Pickering.	July 20.
,, Oxfordian.	Coralline Oolite.	Pickering.	July 20.
,,	Lower Calcareous Grit.	Filey Brigg, Scarborough.	July 23 & 24.
,,	Oxford Clay.	Cayton Bay, Scarborough.	July 22 & 24.
,,	Kelloway Rock.	Newtondale, Redcliff.	July 20 & 22.
,,	Cornbrash.	Newtondale, Scarborough.	July 20 & 24.
,,	Upper Estuarine.	Spa Cliffs, Scarborough.	July 22.
,, Inferior Oolite.	Scarborough Limestone.	White Nab, Gristhorpe.	July 22.
,,	Middle Estuarine.	Gristhorpe.	July 22.
,,	Millepore Bed.	Osgodby, Gristhorpe.	July 22.
,,	Lower Estuarine.	Whitby, Blue Wyke.	July 20 & 21.
,,	Dogger & Passage Beds.	Whitby, Blue Wyke.	July 20 & 21.
Jurassic.	Upper Lias.	Whitby, Peak.	July 20 & 21.
,,	Middle Lias.	Peak.	July 21.
,,	Lower Lias.	Barrow-on-Soar.	May 19.
Triassic.	Keuper Marl.	Lindridge, Leicester.	May 17.
,,	Keuper Sandstone	Groby.	May 17.
,,	Bunter conglomerate.	Gresley.	May 18.
Rhætic.	Bone Bed and *Avicula contorta* shales.	Leicester.	May 19.
Carboniferous.	Coal Measures.	Lindridge, Coton Park.	May 17 & 18.
Cambrian?	Slates.	Bradgate Park, Swithland.	May 17.
—	—	—	—
Igneous,	Syenites.	Groby.	May 17.
or	Felstones.	Bardon Hill.	May 18.
Metamorphic.	Syenitic Granite.	Mount Sorrel.	May 19.

DIRECTORS OF EXCURSIONS DURING THE YEAR 1875.

Mr. George Dowker, F.G.S.; Mr. Calcb Evans, F.G.S.; Mr. J. Logan Lobley, F.G.S. (on two occasions); Mr. John Evans, F.R.S. (President of the Geological Society); Professor J. Morris, F.G.S. (on three occasions); Mr. John Hopkinson, F.L.S., F.G.S.; Mr. James Plant, F.G.S.; Mr. William J. Harrison, F.G.S.; Mr. William Molyneux, F.G.S.; The President of the Association (on two occasions); Major Duncan, R.A., LL.D., F.G.S.; Mr. W. H. Shrubsole; Sir Charles Strickland, Bart.; Mr. C. Fox Strangways, F.G.S., of the Geological Survey; Mr. J. W. Woodall, F.G.S.; and Mr. W. H. Hudleston, M.A., F.G.S.

The thanks of the Association are especially due to the following gentlemen, Companies, and Societies for assistance or hospitality:—Mr. F. W. Rudler, F.G.S.; Mr. R. Etheridge, F.R.S.; Mr. John Evans, F.R.S. (President of the Geological Society); Mr. James Hopkinson; Mr. R. O. Shore; the Messrs. Everard, the Directors of the Coton Park and Linton Colliery and Mr. W. Molyneux, F.G.S.; the Mount Sorrel Granite Co. and Mr. Edwards; Major Duncan, R.A., F.G.S., &c. and Mr. Shrubsole; the Council of the Yorkshire Philosophical Society, and Sir Charles Strickland, Bart.

The Library continues to be extensively made use of by the Members. During the last three years—since a bookcase was provided in the meeting-room—about half the number of books belonging to the Association have annually been borrowed. The educational value of the Association is thus greatly added to by the Library; and more especially as the majority of the works it contains—and which are also, as mentioned in the last Report, in greatest demand—are text-books and standard works treating of the different branches of geological science.

The principal additions during the past year have, however, been the publications of the Societies to which the Proceedings are presented. By this system of exchange, at a small expense to the Association, a valuable library of reference is gradually being formed, and the Members studying the geology of any particular district or formation, are enabled to acquaint themselves with the work of those geologists who contribute the results of their investigations to local societies. The authors of papers contributed to the Association have also their views made far more widely known than would be possible by any other means, each copy of the Proceedings thus presented being accessible to a considerable number of readers in the principal centres of scientific thought and activity.

The alterations in the composition of the managing body of the Association this year are not numerous, but your Committee allude with regret to the fact that Mr. Coombs has found it necessary to resign the office of Librarian, in consequence of an appointment in the provinces compelling him to leave London.

Your Committee have much pleasure in nominating Mr. John Hopkinson, F.L.S., F.G.S , as his successor, and feel sure that the interest which that gentleman has always taken in the affairs of the Association, together with his bibliographic knowledge and tastes, is a guarantee that your Library will still be in good hands.

Your Committee have much pleasure in recommending for election as an Honorary Member of the Association, Sir Charles Strickland, of Hildenley, Bart., whose hospitality and effective services as a Director of the East Yorkshire Excursion last summer, have placed the Association, to no small extent, in his debt. Your Committee also recommend that the President, for the time being, of the Geological Society, be elected an *ex-officio* Honorary Member of your Association.

Your Committee again desire to offer your best thanks to the authorities of University College for the great privilege you enjoy of meeting in this fine hall, as well as for the courtesy and assistance accorded on all occasions.

BALANCE SHEET OF RECEIPTS AND DISBURSEMENTS

For the Year ending December 31st, 1875.

Dr.	£ s. d.	£ s. d.	Cr.	£ s. d.
By Balance, January 1st, 1875		112 16 10	To Printing and illustrating "Proceedings"	92 2 2
,, Admission Fees	24 10 0		,, Miscellaneous Printing, including the "Report"	20 14 4
,, Annual Subscriptions	136 11 0		,, Library	5 9 9
		161 1 0	,, Gas, Attendance, and Miscellaneous Items...	9 11 0
,, Life Compositions		42 0 0	,, Postage, Stationery, &c.	30 18 2
,, Sale of Publications		7 13 6	,, Bought £63 14s. 11d. Consols	59 18 5
,, January Dividend on £126 16s. 4d. Consols ...		1 18 0	,, Broker's Commission	0 1 7
,, July Dividend on £143 14s. 7d. Consols ...		2 3 1	Balance	110 4 0
,, Repayment		1 7 0		
		£328 19 5		£328 19 5

We have this day examined the Accounts of the Geologists' Association, and we find that, according to the accounts laid before us, a sum of One Hundred and Ten Pounds Four Shillings remained in the hands of the Treasurer on the 31st December, 1875.

JAMES TENNANT, } *Auditors.*
JAMES T. B. IVES,

Jan. 17, 1876.

The Report of the General Committee was unanimously adopted as the Annual Report of the Association for 1875.

Sir Charles Strickland, Bart., and the President, for the time being, of the Geological Society, were duly elected Honorary Members of the Association.

GENERAL COMMITTEE AND OFFICERS

Elected at the Annual General Meeting of the Association, held at University College, February 4th, 1876:—

PRESIDENT.

William Carruthers, Esq., F.R.S., F.L.S., F.G.S.

VICE-PRESIDENTS.

Prof. T. Rupert Jones, F.R.S., F.G.S.
J. Logan Lobley, Esq., F.G.S., F.R.G.S.
Prof. John Morris, F.G.S., &c.
Henry Woodward, Esq., F.R.S., F.G.S., &c.

TREASURER.

F. G. Hilton Price, Esq., F.G.S., F.R.G.S., M.A.I.

HONORARY SECRETARY.

Wilfred H. Hudleston, Esq., M.A., F.G.S., F.C.S., &c.

HONORARY LIBRARIAN.

John Hopkinson, Esq., F.L.S., F.G.S., &c.

GENERAL COMMITTEE.

William Carruthers, Esq., F.R.S., F.L.S., F.G.S.
Frank Clarkson, Esq., F.G.S.
Major Duncan, R.A., M.A., D.C.L., LL.D., F.G.S. &c.
Robert Etheridge, Esq., F.R.S., F.R.S.E., F.G.S.
John Foulerton, Esq., M.D., F.R.S.E.
Captain Marshall Hall, F.G.S., F.C.S.
Henry Hicks, Esq., F.G.S., F.R.C.S.
Matthew Hawkins Johnson, Esq., F.G.S.
John Hopkinson, Esq., F.L.S., F.G.S.
Wilfred H. Hudleston, Esq., M.A., F.G.S., F.C.S., &c.
Prof. T. Rupert Jones, F.R.S., F.G.S.
J. Logan Lobley, Esq., F.G.S., F.R.G.S.
Prof. John Morris, F.G.S., &c.
Adam Murray, Esq., F.G.S.
John East Hunter Peyton, Esq., F.G.S., F.R.A.S.
F. G. Hilton Price, Esq., F.G.S., M.A.I.
Jeremiah Slade, Esq., F.G.S.
Prof. Jas. Tennant, F.G.S., F.C.S., F.R.G.S., &c.
John Francis Walker, Esq., M.A., F.G.S., &c.
Henry Woodward, Esq., F.R.S., F.G.S., &c.

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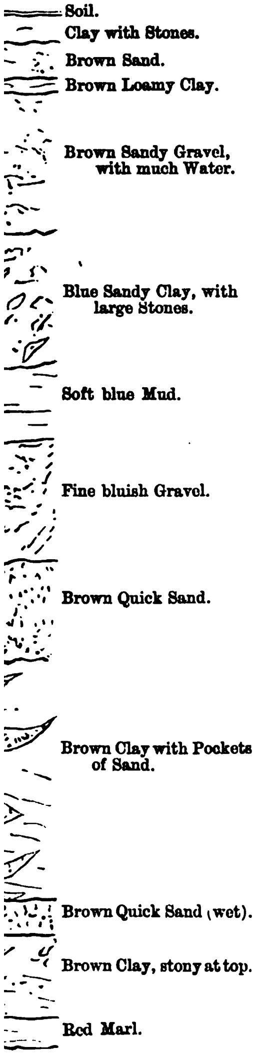
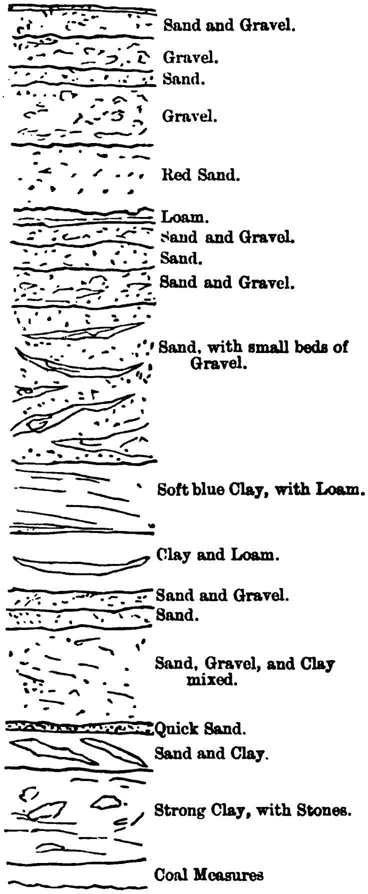


Fig. 7.

Wrexham.



The Thanks of the Association were given to the President, Honorary Secretary, Honorary Editor, and to the other officers of the Association for the past year, for their services, and the Annual General Meeting then terminated.

ORDINARY MEETING, February 4th, 1876.

William Carruthers, Esq., F.R.S., &c., President, in the Chair.

The following Donations were announced :—

"Abstracts of the Proceedings of the Geological Society," Nos. 310 and 311; from that Society.

"Journal of the Society of Arts," January, 1876; from that Society.

"Transactions of the Manchester Geological Society," Vol. xiv., Part 1; from that Society.

"Annual Report . . . . of the Smithsonian Institution, for the year 1874;" from that Institution.

"On a Fossil Saurian Vertebra, from the Arctic Regions," by W. Leith Adams, F.R.S.; from the Author.

"L'âge des couches de Blackdown" (Devonshire), from M. C. Barrois; from the Author.

"Excavations at the Kesslerloch, by Conrad Merk, translated by John Edward Lee;" from the Publishers, Messrs. Longman, Green, and Co.

The following were elected Members of the Association :—

J. H. Cotton, Esq., B.A. Lond.; John S. Elgood, Esq.; Henry Naidley, Esq.; and Lieut. R. G. Warton, Esq.

The following Papers were read :—

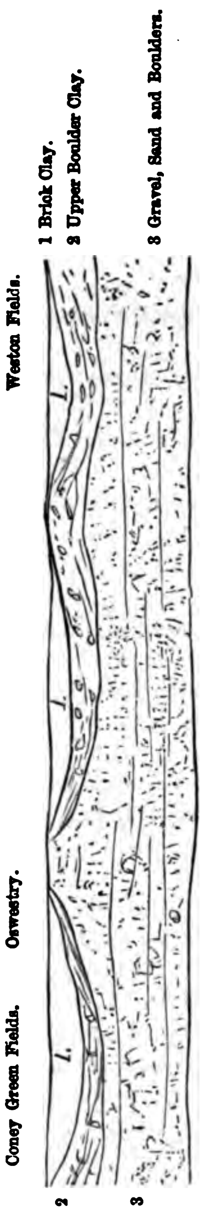
1. On the Drift of the North Wales Border.

By D. C. Davies, Esq., F.G.S.

The various strata of the North Wales Border to which I have referred in former communications to this Association are hidden from sight throughout the greater part of their course by deposits of gravel, sand, and clay, which, grouped together, are usually known among geologists as "Drift."

This covering becomes most complete as we leave the mountainous region of Wales, and pass down the eastern slopes of the border hills to the Shropshire and Cheshire plain. In this low-

FIG. 8.



land, it is only where this overlying drift has been cut through by rivers and streams, or cut and sunk through for mining purposes, that we are at all able to discover the underlying rock.

In traversing the country from east to west, the Drift attains its greatest thickness along a line drawn north and south through the towns of Oswestry and Wrexham; reaching its maximum known thickness—along that line—of about 150 feet between Ruabon and Wrexham. West of this line, generally speaking, it decreases in thickness, the exceptions to this rule being drifted deposits of great thickness, which nestle in the hollows and valleys of the hilly region west of the border hills. With similar exceptions it becomes attenuated also as it spreads itself over the New Red Sandstone plain of Shopshire and Cheshire.

Among the best open exposures of the Drift are Old Oswestry Gravel-pit (Fig. 9), which is 500 feet above the sea, and the gravel ridge of Gresford, north of Wrexham, though the latter is now much covered with vegetation. This is not more than 150 to 200 feet above the level of the sea. The pit section, Plate V, Fig. 7, represents the Drift of this ridge. The pit sections Figs. 1 to 7, which accompany this paper, will afford a detailed view of the structure and composition of the Drift from south to north, between the towns of Oswestry and Wrexham.

Many attempts have been made to subdivide and classify the Drift deposits in various parts of Great Britain, but the attempt is rendered very difficult by the uncertain and locally differing nature of the deposits.

By a comparison of the pit sections, Plate V Figs. 1 to 7, with the Diagrams, Figs. 8 to 13, the following may, I think, be assumed to be the general order in which, on a descending scale, these deposits occur in the district under notice:—

Group I.—*a.* Peat deposit. *b.* Freshwater shell beds. *c.* Brick-clays and redistributed gravels and clays containing marine shell-beds, *d*		Post Glacial Period.
„ II.—Stiff clay, with boulders of both local and northern origin	Upper Boulder Clay.	Glacial Period.
„ III.—A succession of sand and gravel deposits, with beds of mud and clay	Middle Sands and Gravels.	
„ IV.—Stiff clay, with boulders of local and northern origin	Lower Boulder Clay.	
„ V.—Deposits of sand, gravel, clay, and other materials of local origin		Pre-Glacial Period.

We will take the last deposit first, and take the series in ascending order.

Group V is not much developed. Between Oswestry and Llanymynech, where the band of Carboniferous Limestone terminates on the south, the irregularities of that limestone are filled up with a deposit of mud which has been washed out of the shales and marls of the limestones, and which contains concretionary deposits of manganese, iron, and other minerals, that are distributed throughout the limestone series. On the west coast of North Wales these inequalities and cavities are filled with sand* which has apparently been washed and blown in them from the Millstone Grit. Then, as in the Quinta Section, Plate V, Fig. 2, there are fine gravels and sands underlying the tough stony clay which forms the base of the Glacial series. There is not much to be observed in connection with these pre-Glacial deposits except this—that the exposed strata of the district were subject to fluvial and atmospheric action, as we should *primâ facie* expect they would be, before the advent of the Northern Drift with its coeval Glacial conditions.

Before describing in detail the various groups which make up the Glacial division of the series, I would first of all observe generally that, excepting the finer muddy portions of the division, the materials of which the whole is composed are the same from bottom to top. To a man who has been hammering away on cliff and in quarry for twenty years, many chips of old familiar blocks meet his eye. There are the representatives of the ashes, traps, and greenstones of Glyn Ceiriog, together with all the variations of these beds, as they traverse the country westward to the Arrans and Arenigs. To the representatives of this group of rocks must be given the numerical superiority; though doubtless, as we shall see, there are mixed up with them many of similar character from the like rocks in the North of England and Scotland.

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* See Mr. Maw's paper, as given in list appended to this paper.

Next come the Llandeilo and Bala limestones, in all their varieties of texture—coarse and gritty, crystalline and fossiliferous. One cannot visit a gravel pit without observing at once the partially decayed blocks which show us the fossils in all stages of oxidization and decay. With the limestones are found also fragments of their associated strata, together with their interwoven veins of quartz, felspar, and more metallic substances. The Wenlock Shale is well represented from the sandy and somewhat micaceous blocks of Denbighshire Grits, to the flaggy fossiliferous beds which lie near the summit of the group. Almost as numerous as the felstones and greenstones are the boulders of Carboniferous Limestone. Rolled and waterworn fragments of the Lower, Middle, and Upper beds of the North Wales Band abound everywhere. The same is true of the Millstone Grit, with this interesting addition: I have found fossiliferous fragments of the Grit derived from beds I have not yet been able to find *in situ*, and which contain groups of Carboniferous fossils, the parent beds of which are as yet covered and unknown. Fragments of coal, broken off their parent beds when those were exposed, are also plentiful, as are also layers of Carboniferous matter in the finer sands.

To enumerate the fossils—many of which are well preserved—that are found in these boulders would be to give an almost complete list of those belonging to each rock formation, suffice it to say that a nice collection may be formed by repeated visits to almost any gravel-pit.

Besides the stones I have just enumerated, there are, north of the town of Oswestry, numerous boulders and pebbles of granite known among geologists by the name of "Scotch granite." Of these there are three principal varieties. The first is of a deep red colour, from its crystals of red felspar, which are of a large size. These are, I believe, traceable to the extreme north-west limit of Scotland. The next is more pinky in colour, from a larger admixture of white quartz with the red felspar. It is finer in texture than the last, and apparently it does not disintegrate so readily. It bears a close resemblance to the light-red varieties of granite worked near Aberdeen. The third is of a greenish hue shading off into grey, like those of Sutherland, Kirkcudbright, and the same varieties near Aberdeen.

We naturally infer that the means of transport by which these northern wanderers were brought over the border would carry also boulders and *débris* of the rocks with which they were associated at home. It is probable, therefore, as I have already hinted, that many of the syenite, porphyritic, greenstone, and trappean boulders, as well as the *débris* of ordinary stratified rocks, would be brought with the granites from those northern regions. The generic name of the whole assemblage is, as you know, the "Northern Drift."

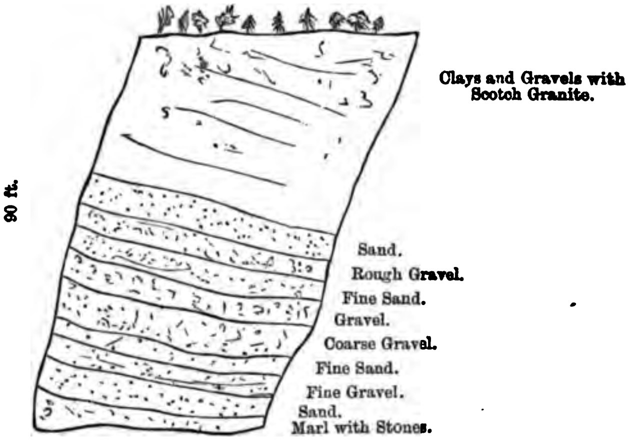
The finer sands of the deposits, I need hardly say, are pulverized quartz and sandstone. The clays are decomposed felspar, and the mud is the re-deposited washing of shales. The whole of the stratified materials have, as we shall see, been mechanically separated, and have been deposited under different conditions.

We will now resume our consideration in detail of the groups into which I have divided the whole deposit, beginning with Group IV.

It will be seen that in six out of the seven sections given the basement of the Drift consists of a deposit of clay which is more or less stony; and I could adduce numerous sections to show that with the exceptions contained in Group V, the basement bed of the Drift over nearly the whole area consists of this stony clay. This clay usually derives its colour from the underlying stratum, or "solid," as it is called by the miners. Over the greater part of the Welsh Border this solid is composed of the Red-marls of the "Upper Carboniferous" or Permian strata; hence the prevailing colour of this basement bed of the Drift is red and brown. Where the overlying gravel is worked it forms the "rommel" of the quarry man. In its lower portion it is free from stones, and graduates in texture into the underlying stratum. Stones appear in it as we ascend, and become more numerous as we approach the overlying beds. In its upper portion it has frequently irregular-shaped deposits of fine gravel and coarse sand, which also increase in number as we ascend. Many of the boulders are of large size, and most of them are rolled, scarred, and striated. They include all the varieties, local and foreign, which I have just enumerated. This deposit I take to be the *true* Lower Boulder Clay.

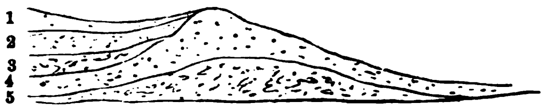
Above this Lower Boulder Clay we have a great and varied thickness of stratified sands, gravels, mud, and clays. As a rule, the sands and gravels are finest in their composition, and are more regular in their stratification near the base of the division. This is well seen in the Old Oswestry section (Fig. 9). They are there interleaved, as I have said, with black layers of coaly fragments, and also of carbonaceous matter, which represents the drifted plant remains and vegetation of the period.

FIG. 9.—OLD OSWESTRY GRAVEL PIT.



Where a sufficient breadth of these gravel and sand deposits is exposed, the regular irregularity, as I may call it, of their stratification is well shown. There are central bosses of sand, with layers of pebbles, shelving off on either side; shelving sand banks, with gravelly deposits abutting against them, as in Fig. 10; wedge-shaped beds of gravel, the materials of which are fine at the thin edge of the wedge, and increase in coarseness upwards towards the thicker end. Then, the pebbles and boulders are, for the most part, smoother by attrition and polished by long travel.

FIG. 10.—OSWESTRY RACECOURSE.

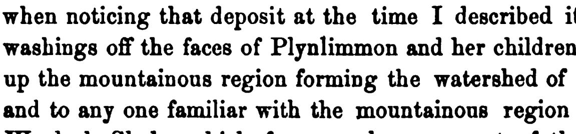


1 Brown adhesive Sand with Scotch Granite.
2 Layers of Sand and Pebbles.
3 Pebbles.
4 Brown Sand.
5 Very Fine Light Brown Sand.

Towards the middle portion of several of the sections there is, it will be seen, a deposit of fine blue mud. It is also met with sometimes in well sinkings near Oswestry. A similar deposit, though probably of more recent origin, is found in the valley of the Severn at Melverley. When the railway between Shrewsbury and Welshpool was in course of construction an attempt was made to make a tunnel through Middletown Hill, near the latter place, but the attempt had to be abandoned because of the presence of a deposit of blue mud—which, perhaps, is more nearly of an age with the mud of Group III—which, when mixed with water, had about the consistency of batter pudding. I mention this because, when noticing that deposit at the time I described it as the fine washings off the faces of Plynlimmon and her children which make up the mountainous region forming the watershed of the Severn; and to any one familiar with the mountainous region made up of Wenlock Shale, which forms so large a part of the counties of Montgomery and Denbigh, it will be quite clear that the blue mud of the middle portion of the section is derived from thence. The clays of Group III are, for the most part, thin and not continuous. They are similar in composition to the Lower and Upper Boulder Clays; for both of which, I fear, they are sometimes taken when looked at in limited sections.

Filling up the inequalities of these Middle Gravels and Clays, the Upper Boulder Clay (Group II) is seen to rest, as shown in Figs. 8 and 11. It is also shown in the right hand corner of Old

FIG. 11.—OSWESTRY RACECOURSE.



1 Boulder Clay with Scotch Granite.
2 Pebbly Bed (9ft. thick.)
3 Debris.

Oswestry Gravel-pit (Fig. 9), and also as occupying the summit under the soil of most of the sections. It varies in thickness from one to twenty feet, and sometimes it thins out altogether, as shown in Fig. 8, the underlying beds coming up to the surface, as they do under a good portion of the town of Oswestry. Where the deposit is thickest irregular beds of sand are often found a little way from the surface. This is particularly the case in the region of St. Martin's, Ifton, and the country north of those places towards Wrexham. It is also distinguished by the presence in great numbers of large boulders, some of which would weigh five or six tons. It is difficult to say, however, whether these large boulders are more numerous in the Upper than in the Lower Boulder Clay, because we have fewer opportunities of examining the latter; but, as far as my experience goes, I think they are more plentiful in the Upper Clay. They stud the surface of the country along the Welsh Border, so that one cannot take a walk a mile in length in any direction without meeting with some of them. The greater part of them are greenstones, porphyritic and felspathic rocks, with Carboniferous Limestone and Millstone Grit boulders from the region west of Oswestry. Rocks of the former class prevail, and many of them are traceable to the particular beds whence they were derived, though doubtless some of them came also from the north along with the granites. These large boulders preserve their original outline, though, of course, the sharpness of their edges is more or less taken off.

Before I notice the brick-clays and other deposits in Group I, an answer may be sought to the question, How came this vast mass of boulders, gravel, sand, loam, mud, and clay where it is; and by what means, and under what conditions, was it all deposited?

That stones grow is a common belief among the peasantry of the Welsh Border; and there is a story told of a Shropshire farmer who claimed to be paid by his landlord for stones the latter was carting off his fields on the plea that by the agreement the tenant was entitled to everything that *grew* upon the farm. We, of course, must seek a different explanation, especially as we have already in part traced the materials back to their original homes.

In attempting to give this explanation, I would begin by saying that there would be first of all the breaking off and the extraction of all these materials from their original strata. Through the whole of the period embraced by the deposits rain would fall, which would wash the fine dust and mud from the hill slopes and other land surfaces. Water would fill original cracks of shrinkage and disturbance in the rock masses. Frost would succeed, congealing and expanding the water, which, with its expansive power, would split off fragments great and small. The sea, also, would fill inlets and creeks, it would undermine cliffs, and wash away the softer beds. Down the mountains, streams and glaciers, now simultaneously and again alternately, and in every shade of combination, would bring blocks, boulders, and splinters to the sea. There were torrents in which the said blocks and fragments would be rolled and smoothed. There were rivers down which mud and silt came. There were shallow creeks into which the whole were brought. Glacier masses broke off at the coast and floated away with their burden of stone. The shallow seas and margins of deeper water froze. Thaw succeeded, and great ice masses from the coast lines, with their imbedded *débris*, floated off to sea, and deposited their burden on the ocean floor. Similar floes like those which now come from the north, and career down the Atlantic, came from the north then, and reaching these warmer latitudes melted and mingled their imbedded stones with those of the nearer regions.

Deposited on the sea bottom the whole of these materials were subjected to a sifting and sorting process, by eddies, currents, and storms, by which means the materials got distributed according to their size, specific gravity, and the depths of the sea. The large boulders remaining for the most part where they were let down ; the small boulders and pebbles rolled by tides and currents in shallow seas, and on shingle beaches and banks; the sand stirred into commotion, floating into deeper water ; and the finest mud held in solution longest settling down at last in still, deep seas.

It will be inferred from a perusal of the sections that, at any given spot in the district now covered by Drift there has been a great variety of oceanic depths and conditions of the water. The lowest clay, with its beds of fine sand and boulders scattered through it, indicates water of a moderate depth. This must also be true of the Upper Boulder Clay. The fine mud in the middle of the sections indicate deep water in a quiescent state, probably over a large area. The beds of rolled boulders and pebbles show a shallow and rough sea, while the loamy deposit seem to indicate land surfaces and some degree of vegetation.

Now a consideration of the phenomena presented by these three groups of the Glacial Period leads us to some important and interesting inferences.

I.—We see how from top to bottom a large portion of the materials are of local origin, being derived from what is now the mountainous region of North Wales, from which we infer that during the whole period embraced by the deposits some portions or other of that country were above water. That its mountains formed an archipelago of islands—an archipelago which, as we shall see, was ever changing its outline, but whose mountains were high enough to sustain glaciers. We infer further that throughout the whole period the sea that washed these islands was not closed and ice bound for long together.

II.—We have seen how from bottom to top of the deposits the Northern Drift is mixed up with that of local origin, and we infer, as in the case of the sea to the west, that the sea to the north was more or less open throughout the whole period.

III.—We see how the entire deposit, with the exception of the loams, indicates—nay demands—marine or aqueous conditions. I do not say that the land was not here and there and now and again bound up in ice—I have already shown such was the case—but I look in vain for anything in the whole range of these deposits which necessitates—nay more, which is consistent with the idea of—a great wide-spread ice-cap mantling sea and land and travelling hither and thither in defiance of all known laws of motion. The phenomena we have been considering do not require its presence, but they do require its absence. Suppose we call in its aid for the formation of either the Lower or Upper Boulder Clay, it would spoil at once for us the stratified sands and gravels which are contained in both. Certainly the middle deposit (Group III) could not be formed by its agency.

Besides the great alternations of level which took place during the deposition of the Glacial Drift, there are evidences in the district we are considering of local alternations of level; of elevations and depressions taking place within a limited area. I will give two illustrations of this. In the drift of the hill Cefn Coch, four and a-half miles N.W. of Oswestry, we find blocks of Carboniferous Limestone and Millstone Grit mixed up with northern boulders. But as the limestone ridges are now some two hundred feet below the drifted blocks, we must infer that a change in the relative height of these hills has taken place since those Carboniferous ridges were high enough for their denuded fragments to be floated over surfaces which now, in near proximity, are two hundred feet above themselves.

Again: on the top of the Oswestry Racecourse, which is three hundred feet above Old Oswestry gravel-pit (Fig. 9), we find, as shown in Figs. 10 and 11, fine sands, with Gravels overlaid by Boulder Clay, which present the same sea conditions and indications of depth as we find in Fig. 9, five hundred feet below them. But as we cannot suppose the same marine conditions existing with a difference of depth of five hundred feet, we must infer that this difference has taken place since the deposition of the beds of Drift; possibly by the elevation of the frontier ridge of North Wales, of which this hill forms a part.

The Scotch granites do not seem to pass southward beyond the town of Oswestry. Sir Roderic Murchison noted this fact in 1839 in his Silurian System. He sought to account for it by the supposed existence of promontories of Carboniferous rocks which, jutting out eastward, barred the progress of the Northern Drift to the south. But the height at which boulders are now found on those supposed promontories, together with the drifted deposits by which they are covered, show that they must have been for lengthened periods under water.

The true cause is to be found, I think, in the force of opposing currents, which here set in from the west and the south, and which turned the northern and western ice-floes eastwards over the Shropshire plain. The existence of these currents is indicated by the prevalence in the Drift of Felton, Baschurch, and the country generally, lying between Oswestry and Shrewsbury; of boulders and splinters of the Bala Limestone and its associated beds, which from the abundance and the grouping of certain kinds of fossils, evidently came from the region lying between Llanrhairadr, Llanfyllyn, and Meifod. The northern granites dovetail westward up the Welsh valleys into the local Drift, but not for any considerable distance. I have noticed them resting, as I have said, on Cefn Coch and on the hill lying between Selattyn and Llanarmon, at a height of 1,400 to 1,500 feet above the present sea level. I have made many traverses of the mountainous region lying west and southwest of these hills, but I have hitherto failed to detect any traces of the granitic boulders. They extend, however, down the western coast of Wales, and I have noticed them, though not of large size, as far south as the centre of Cardigan Bay.

Attempts are sometimes made, from the direction in which the local boulders have, in travelling, grooved and striated the underlying rocks, to trace the sources from whence these boulders were derived.* A little consideration will, however, show that such data are not to be relied upon. For it will be seen that from the frequent local and general alternations in the level of land and sea, such striations are insufficient of themselves to indicate the parent locality of the boulders. Besides, the ice floes in which the latter would be fixed and borne over the sea would be influenced in their course by eddies and currents, and would often tack about like a ship at sea, so that the sharp under projecting points would often scratch the underlying rock, in directions the very opposite from those along which they had travelled.

It is only by a very intimate knowledge of the rock structure of a country that one is able to indicate with any degree of certainty the locality from whence the boulders were derived. In the case of the trappean, felspathic, and greenstone boulders of the district we are considering, this is especially difficult, inasmuch as there is a strong family likeness among similar rocks *in situ* in all their undulations from the Welsh Border to the western side of the Berwyn Mountains and to the Arenigs and Arrans.

It is interesting to notice, however, in Group III, at the mouths of the valleys which run into the heart of Wales, the grouping of the *débris* of the strata through which these valleys wind. For example, the valley of the Morda, which debouches on the plain, one mile south of Oswestry, runs up into the hilly region near Llansantfraid Glyn Ceiriog, where its sources are only a mile distant from the valley of the Ceiriog, which opens out to the plains six miles north of Oswestry. But at or near the mouths of both these valleys *débris* of the red porphyritic rock of Llechrhyddau (Stonefords) in the upper reaches of the Morda, and of Pontymeibion in the Ceiriog, abound. At the mouth of the latter, Bala and Llandovery rock and Wenlock Shales are also abundant, the river traversing these formations. Carboniferous Limestone and Millstone Grit fragments are abundant in the Drift of the Alyn west and north of Wrexham.

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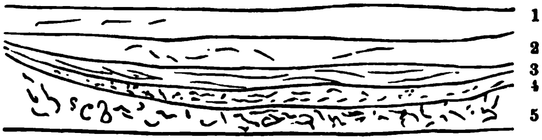
* See Mr. Macintosh's paper "On the Boulders of Llanarmon," as given in Appendix.

I do not know that any marine shells or other fossils contemporaneous with the deposits have as yet been found in these Glacial Drift beds (Groups II, III, and IV). Nor do they contain fragments drifted from the east.

We now come to the consideration of Group I., and we will commence with the redistributed sands and gravels (*d*).

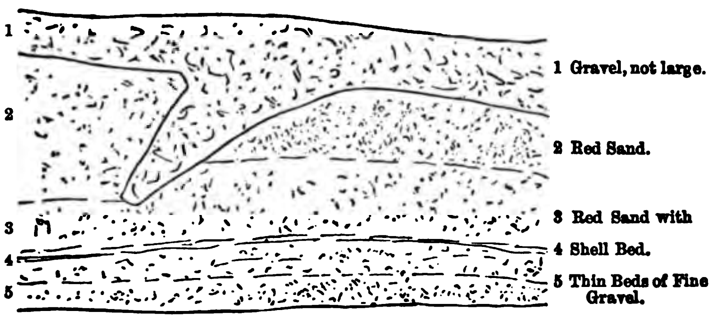
FIG. 12.—DOWNDERRY FIELDS.



1 Soil, 2ft. 6in. to 3ft thick.
2 Peat, 1ft to 3ft.
3 Bluish Clay, 1ft. to 3ft.
4 Shell Bed.
5 Boulder Clay.

After the deposition of the Upper Boulder Clay, and while the high lands along the Welsh Border were only partially submerged, a process of denudation and redistribution went on for a lengthened period, by means of which the materials of the three groups just described were washed out, and deposited either in hollows of the older gravels and clays, or on the New Red Sandstone beds of the low-lying lands to the east. The pebbles are often so mixed up and interstratified with the uppermost loose sands of the New Red Sandstone beds, that one might readily take them for the unconsolidated pebble-beds of the Bunter Sandstone itself. Fig. 13, which is a section of the gravel-pit at Kingsland, Shrewsbury, is an example of this. The red sands have been blown or washed from exposed

FIG. 13.—SHREWSBURY.



portions of the underlying strata, and mixed up in hollows and basins with the redistributed gravels. These gravels and sands are often called, and with much propriety, "Low Level Drifts." Thus the gravel-pit at Kingsland is between three hundred and four hundred feet below that of Old Oswestry (Fig. 9). It is in these redeposited Drifts that the thin beds made up of fragments of recent sea-shells occur, which have been found at Shrewsbury (Fig. 13), Wellington, Macclesfield, Blackpool, and the flat country lying between the estuaries of the rivers Mersey and Dee. As these various deposits are described in the works enumerated at the end of this paper, I need hardly describe them in detail here. I may say, however, that the shells are mostly found in comminuted fragments, and are thus much unlike those of the eastern counties. It has been only, therefore, by dint of much labour that anything like complete lists have been made out. I select the following as a typical list, and also because it is one of shells found in the northern end of the district under notice by a gentleman resident in the neighbourhood :—

LIST OF MOLLUSCA FOUND IN CLAYS AT NEWTON, NEAR CHESTER, BY MR. SHONE, F.G.S., ENUMERATED BY MR. GWYN JEFFREYS, F.R.S.*

1. Mytilus edulis.
2. Cardium echinatum.
3. Cardium edule.
4. Cyprina Islandica.
5. Astarte sulcata.
6. „ borealis.
7. Tellina Balthica.
8. „ calcaria.
9. Mactra solida.
10. Mya truncata.
11. Saxicava rugosa.
12. Lacuna divaricata.
13. Littorina rudis.
14. Turritella terebra.
15. Aporrhais pes-pelecani.
16. Purpura lapillus.
17. Buccinum undatum.
18. Murex erinaceus.
19. Trophon truncatus.
20. Fusus antiqua.
21. Nassa reticulata.
22. Pleurotomaria pyramidalis.

Mr. Jeffreys adds, "All the above, except *Astarte borealis* and *Pleurotomaria pyramidalis,* now inhabit the British coasts, and are littoral and sublittoral. *A. borealis* and *P. pyramidulis* are also more northern species."

A more extended list of the shells found in these deposits throughout the north-western counties is given by Mr. Mellard Reade, F.G.S.† There is also a full account given by Mr. Maw,

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* Quart. Journ. Geol. Soc., Vol. xxx, p. 184.

† Quart. Journ. Geol. Soc., Vol. xxx, p. 27.

F.G.S.,* of similar deposits as they occur in the valley of the Severn below Shrewsbury.

As might be expected, the grouping of these redistributed gravels, sands, and clays would often very much resemble that of the older deposits, and a forgetfulness of this fact leads sometimes, I fear, to the error of speaking of the clays in *them* as Upper and Lower Boulder Clays, and so much confusion and difficulty on the proper classification of the beds is caused.

Of more recent date than the age of the deposition of the redistributed Drift is that of the Brick-clays (*c*), which are extensively worked around Oswestry, and also at intervals northwards towards the sea. They also nestle in hollows in the older gravels and clays, as shown in Fig. 1, which may be taken as a representative section of their mode of deposition. From their comparative freedom from stones or coarse material, we infer that they were gently washed by rains, or by gentle lappings and overflows of water out of the older clays into the hollows where they now lie. I have never found any fossils in them, though, perhaps, more careful searching might be rewarded with success. Of a still later date, and indicative of a time when the land was elevated high enough for fresh water to take the place of salt water in the depressions of the Boulder Clay, are the Freshwater shell-beds (*b*). Fig. 12 is a section illustrative of the mode in which these occur. It is a section which was cut a few years since in the excavation of a reservoir in the "Downderry Fields" close to the town of Oswestry. The shells were all of recent freshwater species. In his "Silurian System," Sir Roderick Murchison mentions a similar deposit which was found under a bed of peat, four feet thick, close to the town of Montgomery, twenty miles south of Oswestry.

This leads us up to the Peat-deposits (*a*), which, I need hardly say, represent the filling up of these ancient freshwater lakes by vegetable matter. The peat in Fig. 12 contained hazel nuts and insect remains. A similar deposit in the valley of the Morda, just below the Oswestry Workhouse, also yielded hazel nutes in abundance. A considerable quantity of bones of a very large size were also discovered in an excavation which was made there some years since, but they were unfortunately sold before any examination of them could be made. It will be observed that this peat in Section Fig. 12, as was also that of the Morda, is covered by stiff clay, with stones shewing a partial resumption of fluviatile conditions in which clay and stones from the surrounding hillocks were washed out and deposited upon the peat.

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* Quart. Journ. Geol. Soc., Vol. xx, p. 130.

It is this fact that leads us to conclude that peat deposits so covered, and which are numerous along the Welsh Border, are of older date than the present morasses of the district, such as Whixall Moss, Welshampton Bog and the like, which are the more recent filling up of lakes and meres like those which abound around Ellesmere, some of which are even now undergoing the process of filling up by the growth of vegetation within them. In peat deposits of the age of that in Section Fig. 12, which nestle among the Berwyn Mountains, I have found branches of oak, interesting from the fact that no oaks now grow at the same altitude in the neighbourhood, nor, indeed, any other tree vegetation. Possibly, therefore, there have been eras of milder climate than even the present during the lapse of the time that has intervened between the close of the Glacial Period and now.

There are beds of recent tufa in the district, and also cave deposits, but these deserve separate notices.

I append a list of books and papers having reference to the subject of this paper:—

Sir Roderick Impey Murchison, F.G.S., in "Silurian System," 1839.

D. C. Davies, "Quarter of an Hour in Old Oswestry Gravel Pit" ("Proceedings of the Oswestry and Welshpool Field Club," 1864).

G. Maw, "On the Drift of the Severn Valley" (Quart. Journ. Geol. Soc., Vol. xx, p. 130).

Mr. Sainter, "On the Drift Beds of Macclesfield" ("Geological Magazine," Vol. ii, p. 365).

G. Maw, "Deposits of Tufa in Flintshire" ("Geological Magazine," Vol. iii, p. 253).

G. Maw, "White Sands and Clays subjacent to the Boulder Drift" ("Geological Magazine," Vol. iv, p. 241).

E. Hull, "On the Parallelism of the Drift Deposits in Lancashire and the Eastern Counties" ("Geological Magazine," Vol. iv, p. 183).

E. Hull, "On Faults in the Drift" (*ibid*, Vol. iv, p. 184).

Miss Eyton, "On an Old Lake Basin in Shropshire" (*ibid*, Vol. iv, p. 1).

Miss Eyton, "On Glacio-Marine Denudation" (*ibid*, Vol. iv, p. 545).

Miss Eyton, "On The Drift Beds of Llandudno" (*ibid*, Vol. iv, p. 545).

Mr. Mackintosh, "On a Sea-coast Section of Boulder Clay in Cheshire" (Quart. Journ. Geol. Soc., Vol. xxviii, p. 388.

Mr. Shone, "On the Discovery of the Foraminifera in the Boulder Clays of Cheshire, with List of Mollusca by Mr. Gwyn Jeffreys" (*ibid*, Vol. xxx, p. 181).

Mr. Mellard Reade, "On the Drift Beds of the North West of England" (*ibid*, Vol. xxx, p. 27).

Mr. Darbyshire, "On a Deposit of Middle Pleistocene Gravel, near Leyland, Lancashire" (*ibid*, Vol. xxx, p. 38).

Mr. Macintosh, "On Boulders near Llanarmon" (*ibid*, Vol. xxx, p. 711).

Mr. De Rance, "On the Drifts and River Valleys of the North and South of England" (Proc. Geol. Assoc., Vol. iv, p. 221).

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2. On the First Irish Cave Exploration.

By G. S. Boulger, Esq.

On Quartz, Chalcedony, Agate, Flint, Chert, Jasper, and other Forms of Silica Geologically considered.

By Professor T. Rupert Jones, F.R.S., Hon. Member and Vice Pres. Geol. Assoc.

(Paper read December 3rd, 1875.)

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§ 1. Introduction.

This paper is not mineralogical in character, but aims at a general treatment of the subject, in its geological aspect, offering a comprehensive view of well-known facts, rather than any novelties. The relation of minerals to their places of occurrence, their modes of formation, and their relative age as parts of the earth's structure, are points of considerable interest, not always treated of by mineralogists, but well worth the study of geologists.

It is not enough to know the composition and mineral characters of many similar and dissimilar substances; the history of their development and of their associations should be carefully worked out. In a collection of articles of *vertu*—whether metal, china, or glass—not only the nature of their substance and their style of art, but their individual and family history, their places of manufacture, their successive owners, and other matters are sought after by the connoisseur. In books of mineralogy there are often blanks in the history of even common minerals—such as quartz, chalcedony, and jasper—as to whether the specimens described or mentioned came from vein, or nodule, or massive rock.

In Dr. Gustav Bischof's "Elements of Chemical and Physical Geology," translated by B. H. Paul, Cavendish Edition, 8vo., 1855, Vol. ii., pages 454 *et seq.*, the chapter on Silica abounds with valuable facts and inferences, original and selected, concerning the origin and collocation of rocks and minerals; and these have greatly influenced geological thought of late years. The following remarks, however, were not written in view of Bischof's extensive repertory of geologico-mineralogical facts; and may therefore be regarded, to some extent, as supplementary in respect of the common geological phenomena of Silica, without being chemical or purely mineralogical.

§ 2. QUARTZ.—After noting the great abundance of Silica in the mineral world, both free and in combination, the author described a few of the salient mineralogical features of its crystallized form—Quartz; and, mentioning some of the largest known crystals, he proceeded to describe its mode of occurrence, and drew especial attention to its presence as a constituent in granite; also in geodes and veins in that and other rocks, mostly old and metamorphic. In the latter, we often have compact veinstones of quartz, showing general crystalline structure on each side, but along the median line, and in cavities, passing into hexagonal prisms, with terminal pyramids, more or less distinct, and varying in translucence. Pyrites, gold, silver, and other minerals are often mingled with the quartz; and rutile, asbestos, hornblende, epidote, mica, chlorite, iron-oxide, bitumen, morsels of anthracite, crystals of calcite, and other substances,* occasionally occur in the crystals, either as fine fibres, flakes, or spots: hence the "Cheveux de Venus, de Thetis, et de Mars," &c., some "cat's eyes," avanturines,* &c. Minute cavities, partially occupied with water, with or without salts of iron, calcium, sodium, &c., are often present; sometimes as films and clouds, called "feather" by the jewellers. Sorby and others have investigated these "fluid cavities."†

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* Bischof gives a full list *op. cit.* p. 477. Cassiterite, pyrites, chalcopyrite, chlorite, and hæmatite are the minerals found enclosed in Cornish quartz, and schorl and chlorite in the Cornish amethyst, according to Mr. F. H. Collins' "Mineralogy of Cornwall and Devon," 1871, p. 87.

The countries where the best specimens of Rock-crystal are found are enumerated in the many books on Mineralogy.‡ The "druses" in the micaceous and other metamorphic rocks of the Alps || are among the best known sources; but similar schists, clay-slates, gneiss, and granites of all mountainous countries yield them. The Carrara marble has cavities lined with rock-crystal; also the Palæozoic limestone of Cape Diamond, near Quebec, and at Fairfield, St. Lawrence county, New York State, and the altered Chalk of Donald's Hill, Antrim, &c. In the Kentish Rag (Neocomian sandy limestone) some fissures are lined with quartz on calcite, as in the very much older rocks at Snailsbeach mine. The Dolomitic conglomerate of the New Red series in Somerset and Gloucestershire contains numerous drusy cavities, and hollow nodules or geodes of quartz, chalcedony, and jasper, together with calcite and other minerals.§ In some nests and veins of quartz the crystals are free in the matrix, and frequently perfect with terminal pyramids; when such depositories have been opened out, their scattered contents supply the numerous crystals known as Irish, Cornish, Bristol, Dungarven, Quebec, Alençon, Paphian (Cyprus), and other "diamonds." Occasionally masses of minute crystals, with or without a matrix,

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* Avanturine quartz, having particles of mica disseminated throughout, may possibly have been a micaceous sandstone, subsequently altered by hydrothermal agency into the more homogenous and crystalline avanturine; or it may have been some form of mica-schist, of metamorphic origin, but further altered into a more crystalline rock, or, lastly, the mica may have been developed by chemical changes whilst an impure siliceous sandstone or schist was becoming highly crystalline.

† Even pseudomorphic quartz crystals (octahedrons and cubes) are found to contain these liquid-cavities: Collins' "Mineralogy of Cornwall and Devon," p. 87.

‡ For British quartz, see Greg and Letsom's "Manual of Mineralogy of Great Britain and Ireland," 1858, p. 82, &c.; and J. H. Collins' "Mineralogy of Cornwall and Devon," 1871, p. 86, &c.

|| Many years ago a great drusy cavity was broken into, on the Alps at Zinken, Savoy, which is said to have yielded 1000 cwt. of rock-crystals; one crystal weighed 800lbs. (Shepard). The crystal-hunters hang over the cliffs by ropes, and strike the rocks for the hollow sound of the druses ("ovens") containing the sought-for crystals.

§ "Memoirs of the Geological Survey Great Britain," Vol. i., p. 246.

occur aggregated, like grains of sandstone. The crystals are sometimes found at considerable distances from their place of origin; for instance, the "Bagshot Diamonds," or subangular pieces of quartz-crystal, in the Post-Tertiary Gravel of Berks and Surrey, have been drifted far, by many stages, whether from the Breton, Cornish, or Welsh area of old rocks. The discrimination of *quartz* from *flint* and other siliceous materials in sandstone—not only by external aspect under a lens, but by the polariscope—is very useful in geological research. When siliceous sand has not only been cemented together as sandstone, but further agglutinated and compressed, after partial softening of the grains, into quartzite, we are led back to pure quartz again, as a variety of quartz-rock distinct in origin from vein-quartz.

The crystal globes of China and Japan, and the Brazilian "pebbles," cut for lenses, mostly come from large waterworn crystals brought down by mountain torrents.

The beautiful purple quartz, or Amethyst (differing somewhat from Rock-crystal in its "rippled" fracture, and its optical properties) is not unfrequent in drusy cavities of old rocks (as in Brittany), in agates, and even in the "potato-stones" of Somerset. A faintly purple quartz lines some fissures in the Kentish Rag at Fairbourne, near Maidstone.

Smoky Quartz,* varying from yellow (cairngorum) to black (morion), is found in the crystalline, metamorphic, and more or less granitoid rocks of mountain districts, just like the pellucid, the milky, and other varieties. Iron, manganese, titanium, and other metals, besides carbon, are supposed to be concerned in giving different colours to quartz. Prase is said to be quartz with green hornblende disseminated in it; rose quartz is probably reddened by manganese; deep-blue quartz is called siderite. Some quartz, when burnt and dipped in a solution of cochineal, becomes beautifully reddened and crackled.†

All these forms of quartz have been deposited by aqueous (probably hydrothermal) agency.

§ 3. CHALCEDONY.—Chalcedony, which is crystalline silica, with varying proportions of alumina, iron-oxide, water, &c., may be said to bear, to some extent, a similar relation to quartz that barley-sugar does to sugar-candy. No definite crystallised structure can be observed; but a fibrous appearance may generally be noted, at right angles to the planes of deposit, which latter are usually lumpy or mamillary, and often render the mass flaky. In some specimens this fibrous structure becomes stronger in successive layers; close-set, minute, crystalline prisms being visible in the fracture of some layers, and these are succeeded by regular quartz-crystals in others. On account of the unequal resistance of some chalcedonies composing agates to the action of hydrofluoric acid, by which certain layers are eaten away, cut agates have been prepared in slabs which take printers' ink and give impressions of their concentric structure, and of the channels of infiltration (see "Transactions of the Royal Academy of Sciences of Vienna," Vol. v., p. 107, pl. 2-4). Speaking of the formation of the angles in "fortification-agates," the author was inclined to accept the hypothesis of the chalcedonic silica having replaced calcite or a zeolite. A portion of an agate, comprising flat transverse layers of chalcedony, with quartz above, enclosing calcite, was exhibited in illustration. The brecciated state of some agates, from pressure, from contraction, or other causes, was noticed, as giving rise to some of the "Ruin-agates." The so-called "Eye-agates" have their name from the exposure of the concentric mammillæ, or sections of invested stalactites, in the nodule. The porous nature of some layers in the agates, and the facilities thus afforded for the absorption of colouring matter, artificially introduced, were alluded to as connected with the minute prismatic structure of some of their constituent chalcedonic layers. (See Hamilton, Quart. Journ. Geol. Soc., Vol. iv., p. 215; and Billings, *op. cit.*, p. 49, &c.) The weathered and waterworn surfaces of broken agates often show the fibrous structure of some of these layers, and the greater relative destruction of some layers than others by water-action.

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* Some smoky quartz is made yellow and of a rich orange tint by burning.

† With indigo, the heated quartz becomes bluish. See Dr. Billings' "The Science of Gems, Jewels," &c. 8vo. London, 1867, p. 57. Thus also heated fluor-spar is dipped in a hot solution of "dragon's blood" to improve the purple tints.

Agates (named, it is said, from the River Achates, in Sicily) are either solid nodules of chalcedony, usually in more or less concentric layers, or hollow nodules (geodes) of the same, with crystallised quartz coating the inner surface (druses), or filling the middle. The central quartz is often amethystine. Sometimes the alternation of chalcedony with quartz in the agates is repeated very distinctly. The origin of some of the wavy outlines in sections of the chalcedony is well seen when it lies on the points of a quartz-crystal layer. In some cases it may have coated calcitic and other crystals, since replaced; in other cases it seems to be due to irregularities on the inner surface of the cavity; and possibly sometimes even to the lumpy formation of colloidal silica. The outer surface of agates is usually coated (in the rock) with "green earth."

Mostly abundant, as amygdaloid kernels, in the amygdaloidal igneous rocks,—namely, vesicular lavas of all ages,—agates also occur in cavities of other rocks, though much less frequently, and more jaspery or opaque (for instance, the agates in the New Red marl and conglomerate of Somersetshire). Chalcedonic infillings of fissures, and irregular cavities in igneous and other rocks, in fossil wood and coral, and in some nodules, are modified agate-formations; and pass through honey-opal, as at Königswinter, and in the Galgenberg, near Oberstein (W. J. Hamilton), to semi-opal and other varieties of opal. In all cases it seems to have been deposited from water holding silica in solution, derived immediately from the rocky matrix, whether traversed by the water, or occupied by it in mass. How far gelatinous amorphous silica has played a part in the formation of agates, and other chalcedonic deposits, is yet to be worked out.

The different layers of chalcedony in agates vary in colour, from white and grey to various reds and browns, and from semi-pellucid to opaque. Some of these are susceptible of alteration in appearance by artificial means—such as application of heat, and the introduction of different substances (See Mr. W. J. Hamilton's Memoir on the Oberstein Agate-quarries: Quart. Journ. Geol. Soc., Vol. iv., p. 214; and particularly Dr. Billings' "The Science of Gems," &c., pages 56-66). Most commonly the ancients soaked broken or polished agates in hot honey for a long period, and then burnt them; and the moderns have treated them similarly, or with boiling oil, followed by vitriol; and the carbonised matter, thus introduced, darkens some layers, and intensifies the tints of some others.* *Onyx*† is such portion of an agate as is coloured like the human *nail* over a white layer; but the layers may vary in tint and numbers. *Sard*[*] is of a fine, rich, subtranslucent red, but varies; it is a bettermost *Carnelian*. *Sardonyx* has coloured layers, of which one must be *Sard*. *Carnelian*[†] is red chalcedony, either from broken agates, long exposed on sea-shore or river-bank, or coloured artificially with iron-oxide.[‡]

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* Tints of blue, green, and yellow are among the colours produced in agates by Dr. Billings, chiefly by salts of iron, as described in his "Science of Gems." The dark carbon colours can also be withdrawn, he explains, and even replaced to some extent; so that an infinite variety of tints are possible.

† This and its fellow words have not been uniformly applied by lithologists, jewellers, and general writers. *See* Dr. Billings, *op. cit.*, p. 66.

At present the principal supply of agates, obtainable formerly in large quantities at and near Oberstein,[||] on the Nahe, between Bingen and Saarbrück, and even in Scotland (the "Scotch pebbles" of the Hill of Kinnoul, Perth), is derived from the river-banks and sea-beaches of India, Ceylon, Brazil, South Africa, &c. The lava-rocks, where, in the first instance, the agates were formed as amygdaloid geodes, in the old steam-cavities, disintegrate, leaving only these hard siliceous nodules to survive the grinding action of moving water. The pebbles so formed are carried down by rivers, and accumulate in their valleys and on the shores of neighbouring seas. The abundance of agate and jasper in the beach of Carnelian Bay, near Scarborough, derived from the Boulder Clay of the cliff, is very noticeable. The diamantiferous agate-gravel of the Vaal and Orange Rivers, in South Africa, has been often before the reading public of late years (Quart. Journ. Geol. Soc., Vol. xxvii., p. 16, &c.).

The series of elaborate papers by Mr. Ruskin "On Banded and Brecciated Concretions and Formations" (in the "Geological Magazine," Vol. iv., p. 337, 481; Vol. v., p. 12, 156, 208; Vol. vi., p. 529; and Vol. vii., p. 10) will prove a most valuable source of facts and suggestions to the student of agates. The papers are illustrated by some exquisite plates and many clear diagrams.

Some very careful and highly suggestive remarks on Silica and the part it plays in petrifaction have been made by Professor A. H. Church, in the "Journal of the Chemical Society," Vol. xv., 1862, p. 107, &c.; and "Journal of the Chemical Society," New Series, Vol. i., 1863, p. 30, &c. His remarks on the artificial silicification of coral, the nature of orbicular silex and beekite; also the action of water in the re-arrangement of materials in cementation, and in the formation of nodules, &c., have induced many to study these questions. The memoir by the late Prof. T. Graham, F.R.S., "On the Properties of Silicic Acid and other analogous Colloid Substances" ("Proceedings of the Royal Society," 1864; and "Philosophical Magazine," Series 4, Vol. xxviii., p. 314, &c.) has extended the field of research on the nature of chalcedonic rocks and minerals, previously opened by observations on the gelatinous form of silica. For English readers we may also allude to De la Beche's remarks on Silica, Quart. Journ. Geol. Soc., Vol. v., p. lxxix., &c.; Dr. Percy, "Swiney Lectures;"* and Mr. J. Sutherland's notes in the "Geological Magazine," Vol. ii., p. 220.

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[*] Said to be so-called from "Sardis," where the treasury of Mithridates was reported to have contained thousands of vases and ornaments made from such agate stones.

[†] *Carniola*, Italian, from *carne*, flesh (Billings).

[‡] Dr. Billings, *op. cit.*, pp. 57 and 67.

[||] See Hamilton, *op. cit.*, and Billings, *op. cit.*, p. 54. The manufactories are continued even where the native supplies are lessened; just as the Scarborough jet works are now supplied from Spain, &c. Agates are found sparingly at some places on the British shores, derived from the Boulder Clay and Drifts, currents and ice, in one form or another having brought them from districts composed partly of amygdaloidal rocks. In Damon's "Guide to Weymouth," &c., and in Bristow's "Glossary of Mineralogy" (article "Agate"), allusion is made to the surreptitious introduction of foreign agates, both on English beaches frequented by sea-side visitors and at places abroad, where tourists expect to meet with such curiosities.

Mammillated and stalactitic chalcedony, as well as drusy quartz, may be seen in cavities of flint; being the result of the re-arrangement of siliceous matter by water. There is likewise a considerable amount of chalcedonic silex in some sandstones, constituting their cement, and thus giving rise to one of the varieties of "Chert." This is often present in such formations as the Upper and Lower Greensands and other sandstones, whether purely sand-formed, or largely composed of fibres and spicules of Sponge.† It also fills fissures, and is sometimes stalactitic in such sandstones. It is a mineralizing agent also in some fossil woods, corals, &c. Green chalcedonies occur, such as chrysoprase and plasma; the former is said to contain some nickel. The greenish Indian "Mocha-stone," or "moss-agate," consisting of clear chalcedony enclosing a fibrous and branching green silicate of alumina, magnesia, and iron (delessite), is found—some of it, at least, together with jasper, bloodstone, &c., among the altered freshwater Tertiary shelly muds, invaded by igneous rocks, near Nagpur (Quart. Journ. Geol. Soc., Vol. xi., p. 359, and Vol. xvi., p. 157). Whole masses of lake shells and *Cyprides* and their matrix, in that region, are replaced with chalcedony, particularly at Nagpur and Chickni, and at Munoor and Nutnoor, in the Sichel Hills. These are probably analogous to the Cypridiferous chert of Purbeck, mentioned by Mr. M. Hawkins Johnson, Proc. Geol. Assoc., Vol. ii., pages 253 and 263.

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* "Chemical News" (1866), Vol. xiii., p. 137, 146, &c., and Vol. xiv., p. 294, &c. With reference to some forms of silicification, Dr. Percy remarks (*loc. cit.*, p. 295)—"Metamorphism may take place by the deposition of matter from solution. Silicification may be taken as an example of this kind of metamorphism. At Kolmar, in Alsace, Muschelkalk in contact with granite is changed into hornstone from the action of springs containing silica. . . . The same thing is observed in Kentucky on a large scale."

† See Dr. Bowerbank's Memoirs, Trans. Geol. Soc., Series 2, Vol. vi., p. 190, pl. 19; and Quart. Journ. Geol. Soc., Vol. v., p. 322, &c.

A living Confervoid *Alga* was actually found to be enclosed in colloid silica, by Messrs. Chandler Roberts and Slack, thus exemplifying what may have occurred in the formation of some of the Indian chalcedonies containing Confervoid substances, indistinguishable from vegetable organisms. Besides delessite, many dendritic and concretionary oxides occur in chalcedonies (Mocha-stone, &c.), and imitate organic forms. Some of these mineral segregations may have been formed contemporaneously with the silica in a gelatinous state; or they may have been enveloped by investing silica; or, lastly, introduced through fissures subsequently.

§ 4. FLINT AND HORNSTONE.—The properties of Flint are somewhat different from those of chalcedony; it is less translucent, more conchoidal in fracture, and never fibrous in structure.* Aggregations of silica are present in every limestone, either in the form of common flint, or as hornstone, or some variety of chert; and are regarded by the author as being due to the replacement of carbonate of lime by silica. As this mineral rarely succeeds calcite (crystallized calcic carbonate) as a true pseudomorph, it is only the amorphous, or detrital, carbonate of lime of the organisms constituting the limestone that has been replaced by silica (as flint, &c.), and not the crystallized material of Echinodermatal † spines, plates, stems, or ossicles, nor the guards of belemnites, nor the shells of *Inoceramus*, *Ostrea*, *Terebratula*,* &c. When such unchanged organisms are abundantly present in flint, or when they have left cavities after removal by water, or when other partially altered organisms abound in the flint, it appears coarse-grained, and is called "Chert." So, also, when limestone of *oolitic* structure (as some of that of Portland† and Durness) is silicified, it forms an opaque, granular, "cherty" flint. Some Hornstones are similar pseudomorphs of silex after carbonate of lime, having, like flint, the original organic constituents of the limestone more or less apparent in their substance, as in the Silurian and Devonian hornstones of North America (Dr. M. C. White: "American Journal of Science and Art," 1862 Series 2, Vol. xxxiii., p. 385). A nodule of flint or hornstone, stated to have come from the Charnwood slates, much resembles Chalk-flint with many dark-grey organic (?) granules.

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* A want of extensive illustrations of the microscopic appearance of flint is much felt. A good artist, well up in natural history, geology, and mineralogy, would find a fine field of work.

† "It frequently occurs in the echinites which are filled with flint, that portions of the shell have been replaced or infiltrated with silex. In all these cases that I have seen, the silex presents a stalactitical or chalcedonic form, and never exhibits the spongeous texture" (Bowerbank, *op. cit*, p. 187). These silicified portions of echinital tests are usually such parts as remain unenclosed by a flint-nodule, enveloping all the rest of the shell (Charlesworth). It seems to the author of this paper, who has lately met with this replacement of the Echinodermatal plates in both enclosed and

Much of the flint of the South of England has been formed out of Chalk-mud full of small sponges, and an infinity of spicules and Foraminifera, which hold the same relative position in the pseudomorph as they did in the original mud or ooze.‡ So, also, groups of echinites,‖ shells, and other fossils occur in flint. Fragments

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unenclosed specimens, that under some rare circumstances the calcitic substance has been replaced by silica, but not with the common *flint* ("spongeous texture," above), but with *chalcedonic flint*, as mentioned by Bowerbank, and such as is described by Bischof among the usual displacement-pseudomorphs of calcite, *op. cit.*, p. 479.

* Oyster and Terebratula shells are not unfrequently replaced by *orbicular silex* in the Lower Greensand and other deposits.

† Dr. Bowerbank insists on the presence of Sponge-tissue in some of the cherty flint of Portland (Trans. Geol. Soc., Series 2, Vol. vi., p. 191), and Mr. M. H. Johnson also describes some spicular chert from Portland (Proc. Geol. Assoc., Vol. ii., p. 254). Some cherty flint of the *oolitic* Portland limestone is free of spongeous spicules or fibres, and some black flint from the Portland rock of Tillywhim is subtranslucent flint, with dark grey organic (?) granules without definite texture.

‡ Compare the flint composed wholly of spicules, Bowerbank, Trans. Geol. Soc., Series 2, Vol. vi., pl. xviii., fig. 3; and the description at pp. 102 and 184, *op. cit.*

‖ Dr. Bowerbank holds that the internal flint-casts of Echinoderms in the Chalk are altered sponges, which grew in the cavities of the dead shells, and often, protruding from the orifices, overgrew the surface more or less, and even joined on to other such sponges (Trans. Geol. Soc., *loc. cit.*); and Mr. M. H. Johnson supports this opinion (Proc. Geol. Assoc. *loc. cit.*). The presence of decomposing animal matter in the infilling Chalk ooze seems to the author to have determined the aggregation of silica in place of calcareous atoms; and such flint is, like the rest, full of the minute Chalk fossils, and not necessarily spongeous, but merely a siliceous pseudomorph of the Chalk-mud. The delicate chalcedonic layer to be met with in the interior of echinites occupied by flint, mentioned apparently by Dr. Bowerbank, *op.*

of *Inocerami* are frequent in some beds of the Chalk, and in the flint of some localities: they lie together in the flint, with other organisms, as they did in the original calcareous mud: in flint-gravel they have been dissolved out, and in fresh flint they may be removed by acid, leaving sharp impressions of the prismatic edges, and casts of the minute tubes and chambers bored by parasites (*Cliona*, &c.) on their substance, and once filled with the chalky ooze.

The fine calcareous detritus which filled the internal canal of encrinital stems, the perforations of echinite tests, the parasitical borings in oyster-shells and belemnites, the tubules of sponges, the cavities of sea-urchins, shells, Foraminifera, &c., has been changed, atom by atom, into exquisite siliceous casts of such hollows and interiors, and are exposed to light by the natural or artificial removal of the calcareous enclosure. In some beds of Chalk the pseudomorphosis of the limestone has taken place near and around sponges; elsewhere, without sponges, large masses of oolitic and of Polyzoan Chalk have been silicified (France);* also Orbitoidal and Nummulitic limestones (West Indies,† Alps, Scinde, Egypt, &c.), Freshwater limestones (Paris, Asia Minor, &c.), and Encrinital limestone (Carboniferous, Britain and Tasmania). The so-called "screw-stones" from the last-mentioned rock (Derbyshire) are the silicified internal casts of the hollow encrinital stems, once filled with calcareous mud; the external mould of the since dissolved calcitic stem being represented by the now siliceous, but formerly calcareous, matrix.

Thus stem, test, or shell, originally of calcite, or arragonite, was not changed; whilst the amorphous carbonate of lime within and around it was replaced by flint, as far as the supply of silica from decomposition and solution of felspathic and other rocks, or from siliciferous springs, could serve. The organisms were subsequently dissolved away when exposed to atmospheric water, leaving vacant spaces. The white surface of a fresh Chalk-flint, of whatever shape it may be, shows by its rough, granular, and subreticular surface, dotted with Microzoa and fragments of shells, the extent of the

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cit., p. 187, and by Mr. Johnson, *op. cit.*, 261, seems to be a partial replacement of the calcitic test [see above]. It is suborbicular, minutely mammillate, granular, and irregularly beaded, somewhat like Mr. H. Slack's fig. 6, pl. 63, "Monthly Microscopical Journal," June, 1874, p. 237, but vastly coarser.

* "Reliquiæ Aquitanicæ," 4to. 1865-75, pages 32, 202, and 249; and Description of Plates, pages 24, 36, 80, &c.

† "Geological Magazine," Vol. i., 1864, pp. 102, &c.

creeping pseudomorphic change between the nodule and the matrix; and the replacement by silica has been through just so much Chalk or other limestone as the nodule or tabular mass represents in size. Even some vertical flint veins in Chalk the author believes to consist of the two altered walls of a fissure, which has been traversed by water with silex in solution; for Chalk fossils remain sometimes *in situ* in such vein-flint.

Dr. Bowerbank has described in detail the sponge-structures observed by him in Chalk-flints (Trans. Geol. Soc., Series 2, Vol. vi, p. 188, &c., pl. 18, figs. 1 and 2); and Mr. M. Hawkins Johnson also refers to definite sponge-tissue as being common in flint; but the author believes that in the South of England, at least, it is rare for sponge-tissue to be itself converted into flint. In most cases, what is commonly called the fossil sponge, represents the calcareous mud once filling the cavities of the sponge, the tissue having generally been lost, or remaining only as a ferruginous stain. Hollows in flints due to the removal of involved sponge-tissue have been lined, by infiltration, with either drusy quartz-crystals or mammillary chalcedony. Sometimes they are filled with the latter, together with some ferruginous mixture, giving rise to the so-called "moss-agates" of the south coast, which contain no moss, and are not agates. The specks, blotches, lines, and some other markings apparent on weathered flint, the author thinks, in many cases, arise from differences in the texture of the flint, due to the various organic substances inhabiting, or buried in, the calcareous mud now represented by pseudomorphic silex. Among such organisms, he suggests that the recent thread-like Foraminifera (*Botellina*, &c.) of the Atlantic ooze may have had their analogues in the Cretaceous mud, giving rise to some straight and cross-lined markings on the weathered surfaces of broken flint, and somewhat similar, but thicker and raised, figures on the outside of nodules. He would not pretend that the subject of silicification was at all mastered yet: flint itself presented many difficulties. Among the questions awaiting solution is the occurrence of crowds of exquisitely perfect siliceous models (*replacements*) of Foraminifera and Entomostraca, both formerly calcareous, and of spicula, which may or may not have been once calcareous, constituting the white dust in the interiors of many flint-nodules. Mr. Joseph Wright, F.G.S., of Belfast, has lately described and figured a fine series of these Microzoa from the hollow flints of Antrim.* It is said that these siliceous spicula, &c., differ under the polariscope from other flint.

In 1840, 1841, and 1849, Dr. J. S. Bowerbank, F.R.S., communicated successive memoirs on the silicification of Sponges and other Zoophytes, and on the formation of flint and other siliceous substances. See Proc. Geol. Soc., Vol. iii., pp. 278 and 431; Trans. Geol. Soc., Series 2, Vol. vi., p. 181; Quart. Journ. Geol. Soc., Vol. v., p. 319. A vast number of interesting facts are here recorded; the author's generalisation, however, that spongeous tissue is *always* present in flint, and has brought about its precipitation, though influencing many geologists, even at present, has been objected to by others, and is not in accordance with the views of the author of the present paper, who has long taught the pseudomorphic origin of flint (after detrital carbonate of lime). See "Geological Magazine," Vol. i., 1864, p. 102 *note*. He has subsequently found it supported by Bischof's statements.†

The replacement of carbonate of lime by silica is strongly urged in Prof. P. M. Duncan's careful exposition of the nature and conditions of the Fossil Corals of the West Indies, Quart. Journ. Geol. Soc., Vol. xx., 1864, p. 358, &c. Both the corallum and the carcareous matrix, in different degrees in different specimens, are silicified. He says (p. 373)—"The process of silicification is doubtless very slow; it is not always perfect, for the silica would appear to have an affinity for bodies formerly organised, and often to destroy the former tissues. Thus there is abundant carbonate of lime in which transposition is not going on around the siliceous fossils, and the persistence of some animal or vegetable organised tissue, decomposing more or less slowly, appears to determine the presence of certain forms of silica; moreover, the details of Corals are often so destroyed by the deposition of homogeneous black flint that this destruction must have commenced after the Coral was imbedded." The conclusions arrived at (p. 374) are worthy of very careful consideration.

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* "Proceedings of the Belfast Naturalists' Field Club," New Series, Vol. i., 1875, pages 73, &c; plates 2 and 3.

† "It is very deserving of notice that carbonate of lime may be displaced by almost all siliceous substances, and, consequently, it is possible that entire layers of limestone may be displaced by silica. This may serve to account for some remarkable instances of the occurrence of quartz layers, the production of which cannot be ascribed to organic agency in the sea. It is probable that siliceous limestone has originated in this manner. But when the carbonate of lime was amorphous, as is the case with most sedimentary limestone, such a displacement cannot be recognised mineralogically." (Bischof, *op. cit.* p. 480.)

Many years since, Dr. G. A. Mantell collected much information on the subject of silicification, as bearing on the nature and origin of Chalk-flint, which he published in the various editions of his "Wonders of Geology," and "Medals of Creation." See especially "Wonders of Geology," 7th edition, 1857-8, pp. 99, 306, 727, &c. Some, however, of Dr. Mantell's own observations are given more forcibly in a paper "On the Microscopical Examination of the Chalk and Flint of the South-East of England," read before the Geological Society of London, and printed in the "Annals and Magazine of Natural History," Vol. xvi., 1845; in which, after noting that shells of Molluscs and tests of Echinoderms do not occur silicified in the White Chalk, and that bones, coprolites, and teeth are usually more or less free of flint, and after explaining his belief that the silica was by no means always associated with Sponges, and was not derived from siliceous organisms (Diatomaceæ, Spicules, &c.), but from mineral springs and the dissolution of felspathic and other rocks, and that the siliciferous water streamed over the sea bottom, at intervals of time, involving numerous small organisms which became fixed in the subtranslucent flint precipitated from it, he goes on to say (p. 80) :—

> "In some slices of flint prepared by Mr. Darker from the Paramoudra of Ireland, Polythalamia are very numerous. The shells or cases invariably appear to be silicified, and the cells of the *dead* shells to be filled with flint. By *dead* shells I mean those in which the animal was dead, and its soft parts removed, and the shell empty, before its immersion in the silex; for I can now bring unequivocal evidence to prove that in many examples the animal itself must have occupied its shell, and all its soft parts been entire at the moment when it became enveloped by the siliceous fluid. A specimen figured in the "Medals of Creation" first directed my attention to this interesting fact; and several specimens, both of *Rotaliæ* and *Textilariæ*, have since been discovered, which confirm the opinion I then ventured to suggest. In illustration of this highly interesting fact, I select on the present occasion an atom of flint (scarcely larger than a pin's head), discovered by Mr. Lee, in which are imbedded two *Rotaliæ*, having the cells filled with a rich amber-coloured substance, that, under a high power, presents a granular structure analogous to that of the body of the recent *Rotaliæ*. In these fossils the soft parts appear to be in the state of *Molluskite*, or they may have undergone silicification, the mineral being coloured by the animal matter. . . . . We find that the pale yellowish-brown or amber colour of many semidiaphanous flints is derived from the soft parts of *Rotaliæ*, *Textilariæ*, and other polythalamian animalcules, ... as the dark veins and markings in the pillars of Purbeck Marble in the Temple Church are attributed to the remains of the soft bodies of the freshwater shells of which that limestone is composed, in the state of *Molluskite* (p. 84)."

In the foregoing extract from Dr. Mantell's Memoir of 1845, the "*Rotaliæ*" comprise chiefly *Planorbulinæ* and *Globigerinæ*. That the yellow and darker colours of flints may be due to the diffusion of the vast quantity of organic matter (sarcode of Foraminifera) buried in oceanic calcareous ooze, is very probable.* The flow of semigelatinous siliceous water over the sea-bottom is, of course, not in accordance with our theory.

Dr. S. P. Woodward's concise and excellent paper " On the Nature and Origin of Banded Flints," in the " Geological Magazine," Vol. i., 1864, p. 145, conveys much information ; but fails to fully explain the substances referred to, some of which—specially those with an axis—appear to be due to the silicification of calcareous mud in and around some such scalariform and subspiral sponges as Dr. Bowerbank obtained from Australia, and such as Mr. W. S. Kent described and figured in the " Proceedings of the Zoological Society," Vol. vi., 1871, p. 616 plate 48 (*Caulospongiæ*). The chalk in the sponge-tissue, and the chalk between the spiral laminæ of the sponge, silicifying with different textures, and subsequently weathering with different appearances.

Mr. M. Hawkins Johnson's Memoir on Flint, in the " Proceedings of the Geologists' Association," Vol. ii., pp. 251-269, 1872, full of the results of careful observation and thought, adds considerably to our knowledge of the subject; but his view of the Flint as a pseudomorph after *Carbon*, especially of Sponges, is not accepted by the author of this paper as by any means fully accounting for all the phenomena of Flint. We have flint after calcareous *oolite*, after Polyzoan polypidoms, Orbitoidal shells, Corals, &c., without any trace of spongeous matter; and, in the first case, without any special quantity of carbon having been present. Heaps of spicula are also silicified, without any order, but continuous with Chalk largely composed of a similar waste of spicules. Again, flint frequently holds a very large proportion of organic atoms and Microzoa, disseminated throughout, as they would be in the original calcareous ooze, and probably representing a fair proportion of such of the original constituent organisms as were not readily replaced by silica. This is notably the case with Foraminifera (as noticed by Mantell—see above), which remain visible when their sarcode persists as an opaque colouring matter, the shell having been replaced by the pervading translucent flint. Much, however, remains to be worked out in this direction. The author fails to find so much spongeous tissue in flint as Bowerbank and Johnson believe to exist there. In adopting for flint the hypothesis of a siliceous pseudomorph of the carbonate of lime, we need not be always asking for sponge-growth, wherever, and under whatever conditions, flint occurs; nor for the violent commingling of Microzoa with sponge-tissue, to account for the presence of the myriads of such organisms in common flint, whether nodules or tabular, or even in the vein-flint of fissures. The relationship, also, of echinites and their flint casts, and of encrinites and "screwstones," &c., becomes simple.

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* See also Bischof, *op. cit.*, p 457.

§ 5. SINTER, HYALITE, AND OPAL.*—Siliceous Sinter, both stalagmitic and granular, resulting from hot siliciferous springs, as in Iceland, New Zealand, Colorado, &c., was next noticed; and it was suggested that some of the flint in the Purbeck "Cap" at Portland may have been siliceous sinter. Hyalite and Opal and its varieties were merely alluded to.

§ 6. BEEKITES AND POTATO-STONES—The orbicular silex of "Beekite" was exhibited as illustrating the deposition of silica in concentric concretions† in and on the surface of angular fragments of limestone, which at the same time it has replaced to some thickness.

The origin of the "Potato-stones," or siliceous geodes, in the Triassic breccia and marl beds of Wells and elsewhere in Somersetshire, is also pseudomorphic; silica having replaced the outer portions of limestone fragments. In some cases, fine and coarse chalcedonies and other minerals have occupied the remaining hollow. Infiltrating water has, also, it seems, formed chalcedonic nests in angles among the Dolomitic breccia.

An examination of the extensive suit of "potato-stones," agates, and other constituents of some Triassic conglomerates, in the Museum of the Geological Society of London, led the author two years ago to recognise the probable—indeed, to him, evident—formation of these geodes and siliceous nodules from fragments of limestone more or less replaced by silica. Mr. Horace B. Woodward, F.G.S., of the Geological Survey, who had been mapping the Trias of South-West England, went over the evidence of the apparent pseudomorphosis and replacements at the same time, and was forcibly impressed with its significance. These "potato-stones" are found in the conglomerates of the New Red Marl at Westbury, near Bristol, at Worle, Clevedon, and Chilcompton, also at Sandford and other villages near Banwell and Cheddar.* Mr. Bristow, F.R.S., has found them in the Keuper Marl at Barry Island, Glamorganshire. At Kenfig Point, Glamorganshire, they are represented in the same formation by "agates" (De la Beche: "Memoirs Geological Survey," Vol. i., p. 243 and 246), consisting of chalcedonic infillings of cavities in the rock, or of the geodes themselves.

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* See Bischof, *op. cit.*, p. 457, &c.

† See Church on Beekite, "Journal of the Chemical Society," 1862, &c.

Amongst the metamorphosed pebbles of some old, much folded, and crushed conglomerates, limestone pebbles have been found to be replaced by quartz under the great pressure they have been subjected to (Hitchcock, Canad. Nat. Geol., 1868, p. 302; and Quart. Journ. Geol. Soc., 1864, p. 125).

§ 7. HONESTONE AND CHERT.—In some honestones we have extremely fine and compact sand, cemented with silica, thus approaching one of the two very different kinds of Chert. Other kinds of honestone belong to metamorphic schists, more or less siliceous, and metamorphosed argillaceous rocks; and some may be of igneous origin, as the Water-of-Ayr Stone.

One of the two "cherts" spoken of is essentially a sandstone cemented with silica; and, in weathered specimens, the grains frequently fall away from the cement, leaving little cavities which add to the coarse-grained or "cherty" appearance of this kind of siliceous rock. The other "chert" is a pseudomorphous silica after detrital carbonate of lime, among which many small organisms and pieces of shells and tests and encrinital ossicles either remain visible, or have left cavities, having been washed out; in either case rendering the rock more opaque and coarse-grained than ordinary flint and hornstone.

§ 8. JASPER.—Jaspers the author was disposed to view, for the most part, as altered clays, though some are opaque chalcedonies. Bloodstone (green and red), riband-jaspers, lydian stone, &c., are especially traceable to clay origins. Beds of shale and clay may be traced into iron-flint (Eisenkiesel), and other jaspery rocks. Specimens from Ballenstadt, Tasmania, &c., were exhibited. The black jaspideous rock now representing the Lias Shales at Portrush, Antrim, Ireland, is an excellent example of the alteration of clay by intrusive igneous rock. See Portlock's "Report on the Geology of Londonderry," &c., 1843, p. 150, &c. So, also, the Liassic lydite of Skye. In Griqualand West, South Africa, there are miles of bedded jaspers, highly contorted, varying in colour and character according to the nature of the original clays and sand-rocks, which were crushed and folded by lateral pressure, and altered by the accompanying hydrothermal agency.* A large pebble of contorted jasper and iron-jasper was exhibited. Such jaspers, lydites, and jaspery schists have great geological importance in many parts of the world, inasmuch they hold up the surface of the country by resisting denudation. Some of the jaspers of Griqualand are associated with chalcedonic layers; and in one instance, at least, these have been found broken up and cemented together, like the ruin-agate of Sicily and Saxony (G. W. Stow's Memoir, *op. cit.*, p. 652).

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* Mr. H. B. Woodward, who gave me some of these localities, believes we may add Axminster also. The Rev. Dr. Buckland's memoir on these Agates, also on the occurrence of jasper and jasper-agates, in a dolomite near Palermo, and on other chalcedonic deposits, will be found in the Trans. Geol. Soc., Series 2, Vol. iii., p. 421, &c. It should be noticed that the "dolomite" of Somersetshire is not an original massive limestone, as Dr. Buckland seems to have regarded it, but an impure calcareously cemented limestone breccia.

§ 9. ORGANIC SILICA.—To organic silica, such as exists in accumulations of Polycystina, Sponge-spicules, Diatomaceæ, &c., only a passing allusion was made.

§ 10. DETRITAL SILICA.—Neither was there time to consider the subject of detrital silica, which plays so important a part in geology, as conglomerate, grit, sandstone, quartzite, &c. Some of the great siliceous conglomerates and sandstones known to geologists were alluded to—such as the beautiful Huronian Conglomerate of white quartz and red jasper. An interesting specimen of compact Bagshot Sand (Sarsden Stone), bearing vertical root-marks, which indicate its having been formed in shallow water, was exhibited, having lately been collected by the author.

Besides granitic rocks, the hard bands of quartzite (impacted sandstone, semi-fused by moist heat), such as the Stiper Stones of Shropshire, and great quartz-veins, like the auriferous "reefs" of California and Australia, were noticed among the sources of siliceous sand and pebbles. In connection with the former (quartzite), the following quotation is of interest, from Mr. Franklin Rhoda's "Report on the Topography of the San Juan

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* See G. W. Stow's sections: Quart. Journ. Geol. Soc., Vol. xxx., p. 630, &c.; plate 39.

Country" (Colorado), "Bulletin U.S. Geological and Geographical Survey of the Territories," Second Series, No. 3, 1875, p. 188:—"Still another point is the fact, that in the metamorphism of the original sedimentary rocks into quartzite, the great natural convulsions attending that process have distorted the strata terribly; so that, as in this particular region, a number of peaks in a small area may each have its strata dipping at a different angle from all the rest. The effect of this on topography may be seen in the sketch from Station 38, in which the peaks are said to be divisible into those with strata dipping south; those, in the centre, with vertical strata; and those, on the other hand, with northern dip. These quartzite mountains are, therefore, peaked and rugged." . . . . "The peculiar crystallisation of the quartzite," it is noted, "has also a marked effect on the forms."

In conclusion, the following excellent description of the old quartzite of Assynt was read. Writing of the Assynt Quartzite,* Professor James Nicol says:—"Generally it is a pure white or yellowish sandstone, composed of fine grains of quartz, mingled with a little felspar or mica. Some portions have a fine purplish tint, as if composed of pounded garnets. The quartzite rests on the Torridon-sandstone, butin many places spreads beyond it to the east, and then covers the gneiss. Hard and refractory, little liable to waste or decay, it remains prominent where softer beds around have been washed away. Hence it appears capping the summits of lofty mountains, rising like snow-peaks into the clear blue sky, and contrasting strongly with the deep red of the lower sandstones. It is thus seen in Ben Eay and the Torridon mountains, where frequent faults have brought up wedges of white and red rocks in singular alternations.† Stronger proof cannot be given of how the ground has been shivered into fragments during the many convulsions it has undergone. But these quartzite mountains become far more impressive on a closer inspection. Their cold, spectre-like aspect when remote is almost warm and living, compared to the bare icy sterility that reigns amid their glens and corries. The rocks, smoothed and polished by ice-action, shine with dazzling whiteness. No flower or tree, scarce the hardiest lichen, can find root or soil in crack or crevice. Rare patches of black moss—blacker from the white basin in which they rest—a few detached stones, broken by the winter-storms from the higher pinnacles, alone diversify the surface. There could scarce have been less life there when the snow *névé* filled the upper corries, and the ice-river flowed down the glens. Strange all this barrenness, sterility, utter absence of life, is the result of the indestructibility of the quartzite. It is dead because the ordinary powers of nature cannot destroy it. It wants the higher organic life, because it lives too long as an inert inorganic mass. Where it is more exposed, where the peaks are more broken, where the coarse angular shingle streams in long rivers down the mountain-sides, or gathers in the hollows, there wiry grass and other hardy plants begin to grow, and a few birds are seen searching for the beetles and mountain insects that even there find food and shelter.

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* "The Geology and Scenery of the North of Scotland," 20mo., 1866, Edinburgh, pages 29-32.

† Quart. Journ. Geol. Soc., Vol. xvi., p. 104, fig. 13.

"In the Quartzite Period organic life undoubtedly existed. Two score years ago Dr. Macculloch* pointed out certain conical hollows, ending in long pipe-like bodies.† These he described as Worm-holes—the prototypes of those seen on the shore—where the lobworm sinks into the sand left dry by the retiring tide. We have seen other smaller holes identical in form with the holes which some small Crustacea on the Kyle of Durness are now digging in the sand washed out of these very rocks. The same sand is now lying in the same place, and beings of like organisation are still burrowing it out for food or shelter. Yet the mind almost refuses to grasp the myriad ages that have intervened. The poor Worm or Insect in its daily occupation was building itself a monument *ære perennius*, a tomb more enduring than king or kaiser—the moral needs not to be drawn!"

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* Trans. Geol. Soc., Vol. ii., p. 461.

† See also Murchison's "Siluria," last edition, p. 166, fig. 28.

ORDINARY MEETING, MARCH 3RD, 1876.

WILLIAM CARRUTHERS, Esq., F.R.S., &c., President, in the Chair.

The following Donations were announced:—

"Bulletin of the United States Geological and Geographical Survey of the Territories," No. 5, Second Series; from Dr. F. V. Hayden.

"Descriptive Catalogue of the Photographs of the United States Geological Survey," Second Edition; from Dr. F. V. Hayden.

"Geognostische Untersuchung des Südural-gebirges," by E. Hofmann and G. von Helmersen; from John Hopkinson, Esq., F.L.S., &c.

"Darstellrug der Uebergangs-formation in Norwegen," by B. M. Keihnan; from John Hopkinson, Esq., F.L.S., &c.

"Quarterly Journal of the Geological Society," Vol. xxxii, Part 1; from that Society.

"Abstracts of the Proceedings of the Geological Society," Nos. 313 and 314; from that Society.

"Journal of the Society of Arts," February, 1876; from that Society.

"Proceedings of the Glasgow Natural History Society," Vol. i, and Vol. ii, Part 1; from that Society.

"Journal of the Quekett Microscopical Club," No. 30; from that Club.

The following were elected Members of the Association:—

Richard Barker, Esq.; Robert William Cheadle, Esq.; William H. Davis, Esq.; N. Heinemann, Esq., Ph.D., F.R.G.S.; and William Ford Stanley, Esq., F.R.A.S., F.R.M.S.

The following Papers were read:—

1. THE BAGSHOT SANDS IN THE ISLE OF SHEPPEY.

By Major F. DUNCAN, R.A., D.C.L., F.G.S., &c.

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2. ON THE MILL HILL CUTTING, SHEPPEY.

By W. M. SHRUBSOLE, Esq.

3. KNOWN FACTS AND UNKNOWN PROBLEMS OF ARCTIC GEOLOGY.

By CHARLES E. DE RANCE, Esq., F.G.S., of H.M. Geological Survey.

Before entering into the more immediate subject which I have the pleasure of bringing before you to-night, it may be well to take a rapid glance over the means by which our knowledge of the Arctic Regions was obtained, and the causes which led to another expedition being considered necessary for the advancement of science. The British Government have despatched no less than six scientific expeditions to explore the North Polar area within the last century, 1773-1845, which on the sad and untimely fate of the last under Sir John Franklin, were followed by fourteen Government and private expeditions devoted to search alone, but which, nevertheless, brought back large additions to our knowledge of the geography and geology of the Arctic area. On the solution of the fate of Sir John Franklin and his brave companions, in 1859, Great Britain withdrew from the task of Arctic research, and the efforts that were made to reach the pole, from time to time, were carried out by other nations. The American expeditions were all made by way of Smith Sound, or the head of Baffin's Bay. The Polaris, commanded by Captain Hall—a small river steamer, with a crew of only twenty-five men—passed up the strait to the north, a distance of two hundred and fifty miles, in one season, and her boats' crews succeeded in reaching latitude 82°16′ N. In the winter quarters of the Expedition, in 81°38′, the climate was milder than further south, and animal life abounded, including musk oxen.

The German expedition, following the directions of the Continental geographers, attacked the Pole from the eastern side of Greenland, reaching the latitude of 77°0′—or but little beyond that attained by the present Sir Edward Sabine in 1823. Formidable ice-barriers on the 80th parallel repelled the Swedish expeditions, made on the northern side of Spitzbergen and Nova Zembla; while the Austrian expedition, which left Norway in 1872, managed to travel on the ice in sledges as far as longitude 82°, and observed continuous land as far north as 83°, but were obliged to abandon their vessel in the ice-barrier of the 80th parallel; but none of the expeditions from Spitzbergen, though carried out with so much determination, skill, and labour, managed to reach so high a latitude as Parry, in his sledge and boat journey from Spitzbergen, in 1827.

It is worthy of note that the first expedition to the Arctic Regions, dispatched rather more than a century since, was organized at the request of the Royal Society, who urged upon the First Lord of the Admiralty, Lord Sandwich, the service the discovery of the North Polar Area would be to the promotion of natural knowledge. At this time the entire Arctic Zone was a blank on the maps, with the exception of a few outlines of Baffin's Bay and a part of Spitzbergen, to which Captain Phipps, afterwards Lord Mulgrave, was dispatched, and in which expedition Lord Nelson served as a midshipman.

In 1818 the Royal Society, prompted by Sir Joseph Banks and Sir John Barrow, impressed on the Government the necessity of further investigation, and the expeditions led by Franklin, Parry, Back, John and James Ross, Sabine, Buchan, Beechey, and Lyons, were the result. Notwithstanding the large number of persons employed in these numerous expeditions, no loss of life occurred over the whole fifteen years. After the discovery of the precise position of the Magnetic Pole by Sir James Ross, in 1831-33, Arctic exploration paused.

In 1845 the Royal Society again urged the necessity of further knowledge of the Polar area, and Sir John Franklin was dispatched in charge of the last scientific expedition sent by Britain to the Arctic Regions, until that which left our shores last year in May.

Glacial Phenomena.

The western coast of Greenland is guarded by a circle of bare bleak islets two thousand feet in height, separated from each other by fjords, through which passes the drainage of the enormous *mer de glace*, which covers the country to an unknown depth, and conceals the rocks beneath—the *inlands iis* of the Danes, which abruptly terminates in steep cliffs—*sermik soak* (ice-wall) of the Esquimaux—three thousand feet in height, where deep glens and fjords penetrate the country.

The surface of the ice field is described by all observers as exhibiting a marked "escaladed structure," as it was termed by Dr. Kant, the ice rising towards the snow shed in a series of steps; but the general effect of the scene appears to closely resemble that of sailing out to sea, for though Professor Nordenskjöld found the ice thirty miles inland to rise to a height of three thousand feet, yet the slope is so imperceptible that in travelling inland the land appears to be left behind, and an interminable ocean of ice encountered. In summer the surface of ice melts to a certain extent, and rivers of ice-cold waters flow over the inland-ice, and fall into crevasses of unknown depth, which are exceedingly numerous, and increase in size and number the further inland the observer has advanced.

Dr. Rink believes that only two inches of the Greenland precipitation of snow and rain reaches the sea in the form of glacier ice, while he estimates the total precipitation at twelve inches; or that evaporation being exceedingly small, nearly ten inches must be carried off by sub-glacial rivers. It is needless to point out the important influence these sub-glacial streams must have on the underlying clay deposits, the *moráine profonde* or *couche de boue* of Agassiz, the result of the trituration of the rocks over which the ice passes. The crevasses descend to a depth of probably not less than two thousand feet; and into one of these chasms, with vertical walls of blue ice, Professor Nordenskjöld and Dr. Berggren found magnificent rivers precipitating themselves and disappearing, at a height of two thousand two hundred feet above the sea, and in a locality thirty miles inland from the coast, in lat. 68°22′ N. It was on the surface of the ice of this area that the observers noticed the grey sandy trachytic mineral *Kryokonite*, associated with a brown polycellular algæ, the dark masses of which absorbing the sun's rays cause the ice to melt and form the deep holes which traverse the surface.

The height of the rock surface of Greenland beneath the ice is exceedingly problematical, but that it is much lower than the circles of islands which fringe the coasts and form a barrier to the inland ice is certain. The Danish settlements are situated on these islands, and on the narrow strip of land between them and the ice-wall, where fjords or valleys intersect the country, the ice pours over and makes its way to the sea as distinct glaciers; the seaward channel generally becomes choked up with the immense quantity of fine material brought down by the sub-glacial streams, flowing out beneath the ice. In most cases the glacier extends far out into the water channel, terminating in the "iis-blink" (ice-glance) of the Danes, from the face of which bergs break off, and plough their way seaward through the drift deposits choking up the channel. Further north, in Melville Bay, Sutherland describes the ice as forming a continuous wall seventy to eighty miles in length and 1200 to 1500 feet high, of which about an eighth is above the water level, the Esquimaux halibut fishers requiring three hundred fathoms of line to reach the bottom of the face of the ice. In lat. 68°, near Claushavn, where valleys come down to the coast, the ice is not less than 2,000 feet in thickness, and the bergs of great size. Still further north, however, beyond Cape York, the glaciers are smaller, the air not being so charged with watery vapour from the Atlantic.

The specific gravity of the sea-water of Davis Straits, according to Scoresby, is 1·0263, freezing at 28½°F., when the salt, 5¾oz. to the gallon, is precipitated, and the "bay-ice" of the whalers formed: this eventually becomes a floe, which, uniting with others. forms "pack-ice." In summer the ice near the sides of a channel melts first, and the strip left intervening constitutes the "middle ice" of the whaler; the left, between the open water and the land, which hangs and clings to the cliffs, forms the "iis-fod" (ice-foot) of the Greenland Danes, which receives large quantities of landslips and other *débris*, which, when the ice breaks up, are carried seaward, on the bottom of which they deposit their stoney freight.

Terraces of Glacial Drift were found by Karr and Hayes at various heights from 32 to 110 feet above the high tide, along the whole coast of Greenland and Smith's Sound. Hollows, also, extending as high as 500 feet above the sea were filled with this clay, which, in some cases, formed banks overlooking the glaciers. The clay contains, in some places, Echinodermata, Crustacea, and Mollusca, of living local Arctic species, with the exception of two—*Glycimeris siliqua* and *Panopœa Norvegica*. In nodules of this clay occur the well-known impressions of the angmaksaett (*Mallotus Arcticus*, O. Fabr.), a fish still living in Davis Straits. Examples of these nodules may be seen in the British Museum split longitudinally; their great density is noticeable from their great analogy to the fossil-bearing ironstone nodules of the Coal Measures.

The icebergs of Davis Straits are described as covered with rocks and boulders, often weighing one hundred tons each, frozen into their mass. Where the bottom of the sea is hard, and the depth shallow, the berg is brought to a stand; and even when the sea bottom consists of soft glacial clay the result is often the same, and a talus is pushed up. These submarine banks constantly increase in size, from the clustering of small bergs upon them, and form the haunt of shoals of cod and halibut and myriads of sharks. In Melville Bay Dr. Brown describes the bergs as reaping immense crops of *Laminaria*, torn from a depth of one hundred fathoms with their seaweed and broken shells of *Mya* and *Saxicava*, which may be thus transported by currents long distances, and these littoral shells deposited in deep water.

No more remarkable fact was, I think, brought back by the officers of the Polaris, than the occurrence of erratic fragments, derived from Fiskernaes, in South Greenland, in the Glacial Drift overlying the Upper Silurian limestone as far north as 81°30′ N. and forming the coast north of the Humboldt Glacier, indicating a distinct drift from south to north. It is also worthy of note, that a large number of freshwater lakes were noticed, inhabited by *marine* Crustacea, indicating a comparatively modern upheaval of this tract thirty feet above the sea level.

A great number of observers have recorded the decided evidence of a subsidence now going on on the west coast of Greenland. Arctander, in 1777, noticed that land in a firth, called Igalliko (60°49′), was submerged at spring tides, though walls five feet in thickness still remained; half a century later the tract was entirely submerged. Houses built in 1721, at the time of Egede, the Apostle of Greenland, have now the sea flowing into them at high tide.

From an early date the peculiar discolouration of portions of the Arctic sea has been commented on by the navigators and whalemen who traversed the frozen ocean. Henry Hudson, in 1607, believed that the sea was blue or green, according to whether ice was present or absent. Scoresby considered that the discoloured water formed one-fourth of the surface of the Greenland Sea, between the parallels 74° and 80° north latitude. He describes the appearance as occurring in long bands lying north and south, and varing in dimension. "Sometimes the transition between the *grass-green* water (with a shade of black) and the *blue* is progressive, passing through the intermediate in the space of three or four leagues; in others, it is so sudden that the line of separation is seen like the rippling of a current." Dr. Robert Brown, to whom it was reserved to discover the cause of this discolouration, noticed that a vessel in the space of a few hours, sails through alternate patches of deep black, green, and cerulean blue; while in the upper reaches of Davis Straits and Baffin's Bay one hundred miles may be traversed with one uninterrupted space of the latter colour. Scoresby believed immense numbers of *Medusæ* caused the discolouration of the water, and afforded the food of the countless "right whales" which frequented the "black water." Dr. Brown, however, found that on several cold days, the *Medusæ*, both large and small, sunk, and yet the water retained its usual colour, and being microscopically examined, was invariably swarming with *Diatomaceous* life, the large proportion of which belonged to a beautiful siliceous moniliform diatom, which is described by Dr. Oberg as having the appearance of a minute beaded necklace, about $\frac{1}{400}$th part of an inch in diameter, with articulations containing a brownish-green granular matter, which gives the colour to the plant, and again to the sea, in which it grows so abundantly. The swarms of diatoms found at the surface of the Greenland seas, in Davis Straits, Baffin's Bay, and in Spitzbergen, do not appear to live in water of any great depth, for even in samples brought up from two hundred fathoms no traces of them were found.

In June, 1861, Dr. Brown noticed that the long brown streaks on the ice, of the breaking up floes, were due to the presence of the same siliceous moniliform diatom, which he found to mainly contribute to the food of the whale; for on examining the alimentary canal of these animals, microscopically, he found the contents to consist of these *Diatomaceæ*, which give the sable hue to the Arctic seas, and also afford food for the smaller Mollusca and Echinodermata. The long slimey bands, resembling the fronds of *Laminariæ*, found by the early whalers, immediately under the ice, were found by Dr. Sutherland to be masses of diatoms, which Dr. Brown describes as filling the cavities which honeycomb the surface of the gigantic floes, and, by generating a certain amount of heat, convert them into cavernous sheets, the "rotten ice" of northern navigators.

Dr. Brown records some interesting observations on the effect of the lowering of the surface-temperature of the sea on the presence of animal and *Diatomaceous* life. On the evening of the 4th of June a pint measure of Entomostraca, Pteropoda, and *Medusæ*, was collected in the towing net in a few minutes, with a temperature of 32·5°; the next morning, in the same position, no ice to be seen, the same air temperature, but that of the sea sunk to 27·5°, no trace of organic life was left.*

The food of the northern whale is *Clio borealis* and *Cetochilus septrentrionalis*, which feed on the diatom which stains the northern seas black, and which is found most plentifully during the calm Arctic nights, during which the greater number of whales are taken whilst seeking the "whales' food."

PALÆOZOIC ROCKS.

Dr. Karl Vrba examined microscopically more than 200 rocks, from South Greenland, brought home by Prof. G. C. Laube, the Geologist attached to the second German North Polar Expedition; they consisted of hornblende and zircon granites, gneiss, eurite, syenite, orthoclase porphyry, diorite, diabase, gabbro, weichstein, and serpentine.

Professor Laube in his Map of the Geology of South Greenland, represents the granite and gneiss as also extending along the East Coast as far as 61° N. These crystalline rocks continue along the whole coast of Western Greenland, from these the Greenlanders derive the steatite, from which they make their lamps, and other utensils. The only exception in the continuity of the gneiss and crystalline rocks, in the coast section of West Greenland and its islands, is the projecting peninsula of Noursoak and the Island of Disco, where sedimentary coal-bearing beds of Cretaceous and Miocene age occur in the hollows and old valleys of the gneiss, from which tinstone, magnetic pyrites, and other minerals have been obtained in Disco. Graphite is also reported in a fine-grained granite, with grey quartz, and felspar of a watery lustre, with garnets.

Should it be proved, that the Gneissic and Granitic Rocks of Greenland are of Laurentian age, it would appear that this tract had been more extensively denuded before the Cretaceous epoch than the Arctic Archipelago,—where the Laurentians are overlaid by the Upper Silurian, Devonian, and Carboniferous rocks and the Lias.

The remarkable fluoride of sodium and aluminium—*Cryolite*—is peculiar to the west coast of Greenland, with the exception of Miask in Siberia. The veins of it occurring at Evigtok, 12 miles from Arksut, were discovered, through weights of this material used in the fishery for capelins, cod, and Arctic salmon (the loddé of the Norwegians), being sent to Copenhagen by Danish missionaries at the beginning of the century. The white cryolite vein is 80 feet in width, and has been worked by Mr. Taylor, F.G.S., fifteen feet from the surface the cryolite was of a dark colour, so that it is probable that the other vein of black cryolite is merely less decomposed. The Greenlanders value the white variety most, which they pound with tobacco leaves, and use the product as snuff. Cryolite is used in Denmark for the manufacture of soda, by mixing it with lime and applying heat; the fluoride is sent to Paris to be used in glass etching. Its use as a source of aluminium, discovered by Mr. Dick in 1856, has since been abandoned in favour of bauxite. The white cryolite vein dips south, with the planes of the gneiss in which it occurs; near the higher portion of the vein, a large quantity of galena occurred, which was worked in 1854, giving 45 ozs. of silver to the ton of ore.

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* "Journal of a Voyager," &c., 1852, Vol. i.

Crystalline rocks form the entire west coast of Baffin's Bay and Davis Straits, from Cumberland Sound to Lancaster Sound, with the exception of Cape Durban, where coal-beds occur, which may possibly be a continuation of those of Disco.

Granite, gneiss with garnets, greenstone and mica schist, were brought home by Ross, from Waigatt Island, the Three Islands of Baffin (74° 1′ N. lat., 57° 28′ W. long.); Cape Melville, Bushman Isle (36°4′ N. lat., 65° 66′ W. long.); between Cape York and Cape Dudley Digges, including the Crimson Cliffs; and from Agnes Monument (70° 37′ N. lat., and 67° 30′ W. long). A large number of specimens were brought home by Capt. John Ross* in 1819, from Davis Straits and Baffin's Bay, and determined by Dr. J. Mac Culloch, who describes the gneiss with green compact felspar, pyrites and garnet occurring at Possession Bay and Cape Byam Martin (73° 33′ N. lat., 77° 28′ W. long.), as being exactly "similar to that which occurs abundantly in the Western Isles, and more particularly on the western coast of Ross-shire, prevailing particularly about Loch Ewe and Loch Greinord," rocks which have since been determined to be Laurentian.

The Granitic and Crystalline Rocks of the Hudson's Bay Territory, described by Sir John Richardson, were believed by Sir Roderick Murchison to be referable to the Laurentian System, and he points out that the rocks which overlie these in the northern parts of this territory, are characterized by the prevalence of Upper Silurian corals of the Niagara and Onondaga Limestone group, the equivalents of our Wenlock and Dudley. From the occurrence of *Encrinurus punctatus*, and the shell *Pentamerus oblongus*, and the absence of any Lower Silurian rocks or fossils in the whole of the known Polar regions, Sir Roderick inferred that the whole district north of the Laurentian mountains was dry land during the Lower Silurian period. In the area to the south, and in the European Lower Silurians, the sea was evidently not deep, and even in Upper Silurian times the depth was not very great, as evidenced by the presence of *Pentamerus*, which in North America is borne out by Sir William Logan's discovery that the Silurian limestones of Lake Temiscamang include enormous blocks of sandstone, on which they rest.

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* "Ross's Voyage of Discovery," &c., 2nd, 1819. 8vo. Vol. ii.

Dr. Conybeare appears to have been the first, in his Report on Geology to the British Association, 1832, to have noticed the similarity of the fossils from the Arctic Regions to those of the English Upper Silurian series. Mr. Salter, after a minute examination of the specimens brought back by the various expeditions, found that though many species found at Wenlock, Dudley, and in Gothland, occur in the Arctic Regions, the facies of the forms is rather American than European.

From the rocks and fossils brought from the Arctic Archipelago by Sir Leopold M'Clintock, and placed in the Museum of the Royal Dublin Society, Dr. Haughton was enabled to draw up a geological map of the group of islands, which I have taken as the basis of that exhibited this evening.

Silurian limestones occupy the south of North Devon, and nearly all the islands south of Melville and Lancaster Sounds, including the south of Banks' Land, Prince Albert's Land, Prince of Wales' Land, King William's Island, North Somerset, Boothia Felix, &c. The limestones of Boothia are chalky, and without fossils; those of Prince of Wales' Land are fossiliferous, and overlaid by bright red ferruginous limestone, interbedded with bright red sandstone, resembling those of Transition Valley in North Somerset. The base of the Silurian in the latter district consists of red sandstone and coarse grit (resembling those of Cape Warrender and Wolstenholme Sound), overlaid by ferruginous limestones with quartz grains, pale-cream-coloured limestones dipping 5° to the N.N.W., forming the terraced arrangement so characteristic of all limestone districts, the effect of weathering on soft shales and hard limestone being well shown in Parry's "First Voyage," where a sketch is given of Port Leopold, by Beechey.

Dr. Hayes obtained 13 species of fossils from the cliffs of Lady Franklin Bay, and Cape Frazer in Grinnel Land, in lat. 81° 35′ N., long. 70° W., which were identified by Prof. Meek as Upper Silurian species belonging to the fauna found in the New York Catskill Shaley Limestone, of the Lower Helderberg group. Some of the species, however, were new to science, as *Zaphrentis Haysii*, Meek, and *Loxonema Kanei*, Meek.

One of the most northern promontories of Grinnel Land is named after the late Sir Roderick Murchison, who, commenting on the collections brought from the Arctic Archipelago by Parry, Franklin, Ross, Back, Austin, Ommaney, the expeditions sent by Lady Franklin, particularly those of Penny and Inglefield, and by the expedition under Sir E. Belcher, endorses the results arrived at by Mr. Salter, that the species exhibited have an American rather than an European facies. These Upper Silurians of Grinnel Land appear to continue across Hall Basin to Hall Land, from which Dr. Emil Bessels, the Naturalist of the American Polaris Expedition under the late Captain Hall, and who had previously served in the Prussian Polar Expedition, collected a number of fossils.*

At Dundas Island, in lat 76° 15′ one of Capt. Penny's crew found a Silurian trilobite and preserved it, tied in his shirt, when the boat had to be abandoned, and a retreat effected. The presence of Silurian rocks at a point so far north, and of sandstones at Wolstenholme Sound, appears to render it probable that the E.N.E. strike of the Carboniferous strata, with the overlying Liassic patches, is cut off eastward, and the Silurian rocks surround them in a basin-like form, an E.N.E. synclinal running through Prince Patrick Island towards Hayes Sound. Detailed examination of the West Coast of Smith Sound and Kennedy Channel will have great geological interest, as it will prove whether such a synclinal exists, and if so, whether the Carboniferous rocks are brought in by it, and whether the Lower Coal-bearing measures are present on both sides of it, and in what manner they rest on the Silurians of Grinnel Land.

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* For calling my attention to these observations, I have to thank Captain Feilden, R.A., Naturalist of the senior ship of the British Arctic Expedition.

The Upper Silurian rocks of Banks' Land are overlain by close-grained sandstone, striking N.E. and E.N.E., with their coal seams. These were first discovered by Parry in the group of islands named after him; the fossils from this series are similar to those of the Irish Calp series and the Eifel, and forms the "Ursa Stage" of Heer. The sandstones are close-grained and white, and with their associated coals strike across Melville Island, and Bathurst Island, where they were noticed by Austin and Belcher. On the south-east corner of Melville Island several seams occur, the coal burns with a bright flame and much smoke, resembling some of the gas coals of Scotland.

On the beach of North Cornwall, Belcher found granite pebbles of a kind, Dr. Haughton states, not occurring in any other part of the Arctic Regions; and inland he observed ravines consisting of sandstone with large masses of clay-ironstone, septaria, and lumps of coal. Considering that this land is on the strike of the limestones of the Carboniferous age of Prince Patrick Island, the northern portions of Melville Island, Bathurst Island, and Grinnel Land, and North Devon, and that Exmouth Island, in Belcher Channel, consists of limestone dipping, capped with Lias, it appears probable that the sandstones of the Ursa Stage of the southern portions of the islands just mentioned, are of similar age to those of North Cornwall, but separated from them by a synclinal depression filled with Carboniferous Limestone, with an axis ranging E.S.E. and W.N.W., of older date than the deposition of the Lias.

Dark ferruginous shales, clay-ironstone and coal were also brought from Buckingham Island (Victoria Archipelago), by Sir Edward Belcher, and Dr. Haughton states they closely resemble those from Liddon Gulf, on the west side of Melville Island, which would appear to place the position of the axis between this island and Exmouth Island, or about 10° north of west.

In Ohio a transition between the Devonian and Carboniferous floras takes place, but in Eastern America the Lower Carboniferous Coal Measures (Calciferous Sandstone of Scotland), lie unconformably on the Devonian.

From an examination of the fossils from the rock exposures of the Mackenzie River, between Clearwater River and the Arctic Ocean, Prof. Meek has determined these rocks to be of Devonian age, and to correspond to the Hamilton formation and Geneses slate of the United States. From the Mackenzie slates many new corals and brachiopods were obtained, also a cephalopod, *Gyoceras Logani*, collected by the late Mr. R. Kennicott. The slates contain brine springs and petroleum, and it is believed that they extend from Rock Island, Illinois, to the Arctic Sea, a distance of 2500 geographical miles, with identical fossils throughout the whole of the tract, proving a uniformity of conditions in these old Palæozoic times prevailing over a very large area.

It appears exceedingly probable that the coal-bearing beds of the Arctic Archipelago are a continuation of these rocks, and are referable to the "Ursa Stage" of Heer, who believes that this stage is referable to the Lower Carboniferous age, from the fact that not a single species of the Upper Devonian *Cypris*-shales of Saalfeld in Thuringia, exists in the Bear Island flora, which is characterized by *Calamites radiatus*, *Lepidodendron Veltheimanum*, *Knorria acicularis*, and *Stigmaria ficoides*, all of which are found in the Yellow Sandstone of Kiltorkan, and should the latter prove to be of Lower Carboniferous age, considering the persistence of freshwater genera, the occurrence of the Old Red Sandstone of Scotland genera of fish in the Kiltorkan beds is not remarkable. Should, however, fish and plant remains be found in the strata overlying the Upper Silurians of the Arctic unknown regions, their specific determination or that of the associated forms, may be expected to throw much light on the vexed question of the exact position of the line of demarcation between Devonian and Carboniferous. The presence of *Knorria acicularis* in the Melville Island flora, is a link between the flora of the South of Ireland and that of Bear Island, and the latter is undoubtedly an outlier of the Lower Carboniferous coal tract of Russia. Looking to the fact that the rocks yield the first rich flora of the earth's history, and to the number of species which can be traced both in the old world and in the new, from 47° to 74° and 76° north lat., there is evidence of wide-spread continental conditions, occupying much of the temperate, as well as the Arctic zone, over which continent ran large rivers, tenanted by freshwater mussels *(Anodonta)*, and neuropterous insects.

From the plants and specimens collected by Professors Nordenskjold and Malmgren, in Bear Island, the following classification of the rocks of the island has been established:—

MILLSTONE GRIT.—Siliceous schists.

MOUNTAIN LIMESTONE.—*Productus*-limestone, *Spirifer*-limestone with gypsum, resting on *Cyathophyllum*-bearing limestone, with dolerite, possibly the equivalent of the Carboniferous Shale of South Ireland.

URSA STAGE of O. Heer.—Sandstones with shale and coal-seams. All the beds contain coal-seams.

DEVONIAN.—Russian Island Limestone, red shale.

The "Ursa Stage" Prof. Heer correlates with the Kiltorkan beds in Ireland, the Greywacke of the Vosges and Southern Black Forest, and the *Spirifera Verneuleii* shales of Aix, and the sandstones of the Arctic Archipelago. This stage he regards as Lower Carboniferous, the base of which he considers to be beneath the Yellow Sandstone; but Sir Charles Lyell, from the fact that these sandstones at Durn Den, in Fife, and in the County Cork, contain the exclusively Devonian fish *Asterolepis* or *Glyptolepis*, believe these deposits to be Devonian, which opinion Mr. Carruthers also expressed in regard to the plants of the Irish and Bear Island deposits.

The subsidence which brought in the deposition of the Mountain Limestone, and the existence of extensive coral reefs equally affected the Arctic Zone, and these formations are well represented in the islands of the archipelago, Spitzbergen, and Bear Island. In the latter, the continental conditions expressed by the European Millstone Grit, are represented by the schists, during this period many Ursa-stage plants still lived on in Europe, proving that islands existed covered with the old flora throughout the whole of the time occupied by the deposition of the Mountain Limestone.

It is clear that the climate of these Arctic regions must have been far warmer than at present, even if the darkness of the long winter nights was the same as now, for Prof. Heer has pointed out that the leaves of the evergreen tree *Lepidodendron*, and the large fronds of *Cardiopteris frondosa*, are as fully developed as those from the South of Ireland and the Vosges.

The hard red sandstone of Igal'iko and of the fjord of Tunnudleorbik, discovered by Dr. Pingel, the geologist attached to the Danish Expedition of 1828, in lat. 61° N. in South-west Greenland, is believed to be of Devonian age, the rock consists of fused quartz particles. This is probably the same bed as that observed in the last-mentioned locality, by Prof. G. C. Laube, the geologist attached to the second German North Polar Expedition, who describes the red sandstone as associated with *Amphibolite*, and a large area of hornblendic granite, with a narrow belt of zircon granite intervening between it and the sea.

The first discovery of Lias fossils in these high latitudes, was that by Lieut. Anjou, of the Russian Navy, in New Siberia, on the north coast of Asia, in 74° N. lat., described by Wrangel. The fact appears to have remained unnoticed until Belcher's discovery of a patch of Lias on Exmouth Island (77° N. lat., and 95° W. long.). The base of this island is soft sandstone, overlaid by Carboniferous Limestone, dipping west at 7°, containing *Zaphrentis, Spirifer Keilhavii.* Resting on this, at a height of 570 feet above the sea, occurs the Lias, in which Belcher discovered the ribs and vertebræ of an *Icthyosaurus*, stated by Prof. Owen to be near to *Icthyosaurus acutus* of the Whitby Lias. From this island, and from Table and Princess Islands, between North Cornwall and North Devon, and from Depôt Point, on the north coast of the latter a large number of other Lias fossils were obtained by Sir Edward Belcher in 1855, which were described by Mr. Salter.

Another remarkably fossiliferous patch, resting on Carboniferous Limestone, has since been discovered at Point Wilkie, in Prince Patrick's Island. Lias resting on Carboniferous Limestone with ferruginous and siliceous grits also occurs at Eglinton Island, between Prince Patrick's and Melville Island. A large number of Lias fossils have been brought to England by Sir Leopold M'Clintock and the late Admiral Sherard Osborne, including *Ammonite Maclintockii*, of Haughton. Point Wilkie (Prince Patrick's Land, 76° 20' N. lat., 117° 20' W. long.), consists of Carboniferous limestones and sandstones, with bands of chert, believed by M'Clintock to be of the same age as those of Melville Island, for at Point Wilkie these are overlaid by reddish limestone with casts of shells, amongst which Dr. Haughton determined *Ammonites Macclintockii*, *Monotis septentrionalis*, and other Liassic forms.

In East Greenland occur Jurassic marls and sandstones on the east and south side of Kuhn Island. Calcareous sandstones, with organic remains, are found on the south coast of False Bay; the sandstones are coarse and alternate with shell-breccias with coal-seams,—the whole series rest on the Crystalline rocks, which form a high ridge with glaciers. The finer-grained Jurassic sandstones contain casts of *Goniomya v-scripta* (Sow.), *Ostrea*, *Myacites* sp., and are possibly the equivalents of the carbonaceous Jurassics of

Brown, Mull, and Sky—"Middle Dogger" (?). In the sandstones of the southern coast of False Bay occurred a *Rhynchonella* perfectly agreeing with *Rhynchonella fissicostata*, Suess, a characteristic Rhætian form; the brown-coal occurred associated with these rocks.*

It is remarkable that the Jurassics on the east coast of Kuhn Islands contain a fauna very nearly allied to the Russian Jurassics, containing the characteristic genus *Aucella*, which is frequent in all the Russian Jurassics, from the Lower Volga to the mouth of Petschora, and is represented in Spitzbergen by the species *A. Mosquensis*. The western limit of this genus is the east coast of Kuhn Island, where five varieties of *A. concentrica* are connected by intermediate forms. Other fossils occurring here are *Ammonites perisphinctes*, Payeri (a very highly involute form), *Belemnites Panderianus*, D'Orb., *B. absolutus*, Fisch., and a *Cyprina*.

In Spitzbergen, Professor Nordenskiöld has described a series of rocks 1500 feet in thickness as being of Triassic age: they consist of black bituminous shale, stratified hyperite limestone, bone beds, and sandstones. The analogy of these deposits to the European Rhætic and Lias is at once apparent, and is borne out by the occurrence in these rocks of *Icthyosaurus polaris*, Hulke, *Icht. Nordenskiældii*, Hulke, and *Hybodus Spitzbergensis*, named and described by Mr. J. W. Hulke, F.R.S., and still further supported by the association of these reptiles and fishes with ammonites. Over these rocks occur another 1200 feet of Jurassic deposits, consisting of shales, limestones, and sandstones, giving at Mount Agardh the thickness named.

The *Atane*, or Upper Greenland Cretaceous beds of Nordenskjöld, occur on the southern side of the Noursoak peninsula, between Atanekerdluk and Atane. Dicotyledonous leaves occur, one being very near to the species *Magnolia alternans*, Heer, from the Upper Cretaceous of Nebraska: these do not occur in the lower or Kome strata, and appear to point to a "limit fauna" occurring in the Arctic Cretaceous beds, corresponding to that found in the European Gault, in which dicotyledonous plants make their first appearance in Europe. To the Atane beds belong the thick coal of Atane, 750 feet above the sea, the Ritenberg coal of Kudliset, and the retinite beds of Hare Island.

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* Zweiter Band, Wissenschaftliche Eryebnisse. Zweite Abtheilung. Leipzig, 1874.

Three analyses of the coals from Disco are recorded, but whether of Cretaceous or Miocene age I do not know. No. 1 is by Professor Fyfe, of Aberdeen; No. 2, by Mr. Keates, of London; and No. 3, by Professor H. Wurtz, from a specimen brought by the U.S. steamer Juniata, in 1873:—

		I.	II.	III.
Gaseous or volatile matter		44·45	50·60	35·38
Moisture		·75	...	14·00
Sulphur		·55	...	trace.
Coke	Fixed Carbon	47·75	37·86	41·79
	Ash	5·50	9·54	8·33
		100·00	100·00	100·00
Specific Gravity		1·369	1·384	

The coke is non-caking and useless.

The basalts, ferruginous clays, sandstones, and brown-coal of Disco Island were first described by Sir Charles Giesecke, F.R.S., in the "Transactions of the Royal Society of Edinburgh" for 1874. The later researches of Professor Nordenskjöld and Dr. Brown have conclusively proved these basalts to be all of Miocene age, and deposited, according to Nordenskjöld, in the form of volcanic ash and sand, since consolidated by pressure, which has caused the rock to assume a crystalline structure. Associated with the basalts are thick beds of clay, which at Atanekerdluk, at a height of 1000 to 1200 feet above the sea, yield a vast number of plant impressions. The strike of the strata corresponds to the direction of Waigat, across which it extends to Disco Island, where it forms the east coast as far as Godhavn, consisting of sand-hills 2000 to 3000 feet in height, with their horizontal bands of coal, and erect bitumenized trees. No coals of economic value appear to occur in these Lower Miocenes, which rest directly on coal-bearing Atane strata; above these plant-bearing Lower Miocene clays and soft sandstones occur several thousand feet of basalt, on which rest the higher coal-bearing strata of Ifsorisok and Assakak of Middle Miocene age, the coals cropping over on the tops of the high fells.

Professor Nordenskjöld found the Greenland meteorites, spread over an area of two hundred square miles in the south-west corner of Disco, to occur both in areas occupied by granite and gneiss, and that consisting of basalt, which latter he found to often contain fragments of the meteorites, which must have fallen, or been forced into cracks, before the basalt tuff was consolidated, and must, therefore, have taken place during Miocene times. The large meteorite in the British Museum from this locality weighs about 87 kilogrammes, while the largest observed by Nordenskjöld probably weighed no less than 21,000 kilogrammes.

Nauckhoff analysed ten rocks from Ovifak, and found the basalt to be of a compact greyish-green colour, composed of felspar (anorthite) penetrating magnetite, augite, and iron, the mass containing 49·18 per cent. of silicic acid. Tschermak describes the augite as of a light green tint, and as filling in spaces between other materials, the felspar crystals being transparent, and filled with some transparent substance; and he compares the Ovifak rocks, with the meteorites of Juvinas, St. Petersburg, and Stannera. Dr. Flight, who quotes these authors, further compares them with the old augite and anorthite lavas of Java, Iceland, and the Eifel.

Amongst the specimens brought from Baffin's Bay by Captain Ross were several implements, or flat stones, composed of porphyritic gréenstone, used by the natives of the Arctic Highlands in cutting off masses of iron from a mountain called "Sowallick," twenty-five miles inland from Cape York, lat. 76°12′ N., long. 53° W. This iron Dr. Wollaston estimated to contain between 3 and 4 per cent. of nickel, and Mr. Fyfe found in it 2·56 per cent., from which they believed it to be of meteoric origin. It occurred to Captain, now Sir Edward Sabine, that these masses of iron were of meteoric origin, and knives made of it, given to Sir Joseph Banks, were examined by Mr. Brande, and found to be free from rust, and to have the peculiar silvery appearance of meteoric iron and to contain more than 3 per cent. of nickel.

Prof. Nordenskjöld comments on the complete agreement between the character of the basalt from West Greenland and the British Isles, and the certainty of the identity of the geological age of the two, and suggests that a continuous tract of this formation, extends across Greenland to the cliffs on the east coast, from which Scoresby obtained his plant impression, and from which the last German Expedition brought back basalts and Miocene plants coeval with those of Disco, thence by way of Jan Mayen to Spitzbergen, and from Jan Mayen by the Faroe Islands to the Hebrides and Ireland; and also suggests that this line marks a volcanic mountain chain, which limited the Miocene Polar Continent, in the way that similar chains now fringe the western coast of America, and the eastern coasts of Asia.

The observations of Lieut. Julius Payer and Dr. Copeland in East Greenland, and the report on the specimens brought by them from that coast between lat. 73° and 76° N., and reported on by Dr. Fr. Toula, is of great interest as bearing on this question. Crystalline rocks, sometimes associated with fine-grained gneiss, constitutes the greater part of the coast and the inland mountains observed. The coast is cut back into deep fjords extending far inland, at the mouth of which are a group of islands, some of which, as Shannon Island, are of volcanic origin, while in others various Mesozoic and Tertiary formations are associated with the crystalline rocks, or rather rest upon them.

The Basalts extend along a line ranging N.E. to S.W., beginning on Shannon, and continuing through Sabine and Pendulum Islands—the protruding peninsula between False Bay and the Tyrol Fjord, the eastern side of Clavering Island and Jackson Island, as far as the coast between this island and Capes Broer Ruys and Franklin. The basalts are both of the dolerite and anamesite (genuine peridotic) groups of these rocks, and occasionally basalt tuffs occur, with zeolites and double refractive calcite. The basalt is described by Payer, as forming immense plateaux capping the hills; it will be noted that a prolongation of the direction of these basalts across Greenland, emerges on the west coast, precisely where the basalts of Disco are found.

The Miocene Beds exist at the base of the crystalline ridge from the south end of Hochstetter's Foreland to the south of Cape Seebach, rising to a height of 300 to 500 feet. Overlying the rocks of the Ursa Stage of Spitzbergen, are the Miocene Beds, which have yielded so rich a fauna and flora to the various expeditions which have visited them. At King's Bay a lime (*Tilia walmneni*), a juniper, and an arborvita (*Thuites Ehrenswaerdi*) occur—many of the species occur in West Greenland—and two of them were found by Lieut. Payer, in the fossiliferous marls of the Germania Mountains in Sabine Island, East Greenland, viz., *Saxodium distichum*, and *Populus Arctica.* It is worthy of note, that at the present time, firs and poplars grow in an area 15° further north than plane trees; so that assuming the former to have reached their northern limit in Spitzbergen, in lat. 79°, the latter may have grown provided there was land, as far north as the Pole.

Lieut. Payer states that the newly discovered Frantz-Joseph Land equals Spitzbergen in extent, consisting of several great masses of land, separated by Austria Sound. Broad horizontal sheets of dolerite, identical with that of North-East Greenland, form steep table mountains. The rocks in the north are coarse-grained, and contain nepheline; those in the south are appanitic in their structure, and pass into true basalt, the mountains here being about 5000 feet high, while those in the north only attain 2000 to 3000 feet. Tertiary sandstone, with brown-coal, occurs, so probably the basalts may be of Miocene age. The depressions between the mountains are filled with gigantic glaciers, which form mural precipices on the coast 100 to 200 feet in height; the glaciers were found to be characterized by their greenish-blue colour, the paucity of crevasses, the coarse grain of the ice, slow motion, thickness of annual layers, and the small development of moraines. Geographers of Petermann's school, believe the abrupt mountainous coast of East Greenland trends away to the north-east, north of Parry's furthest point of Spitzbergen, and a writer in the "Academy" (Sept., 1874), has suggested that in Franz-Joseph Land may be the eastern termination of this coast-line.

The Miocene of Spitzbergen and Franz-Joseph Land extended probably across the Polar tract itself, for on the banks of the Mackenzie, we find Miocene plants and coals, described by Sir John Richardson as associated with potter's clay and sandstones, while on the north coast of Siberia, the so-called Wood Hills, discovered by Sirowatskoi, in 1806, are stated by Wrangel to consist of horizontal beds of sandstone, alternating with vertical trunks of bituminized trees, forming a hill 180 feet in height. Amongst the proofs of the former continuity of Miocene land, is the fact of the occurrence in Greenland of the Japanese genera *Glyptostrobus* and *Thujopsis*, while east *T. Europæus* occurs in Europe, both in the Baltic amber, and at Armissan (Narbonne); associated with it are American forms, which Prof. Göppert has pointed out, are species which are found associated with the amber pines of the tract now under the south-east corner of the Baltic.

In the Upper Miocene beds of Œningen, North American types still live, amongst them is a vine, four palms of the American type, and conifers *Sequoia* and *Taxodium*. The palms, both of the European and American type, and other exotic forms, are found to be absent in the Miocenes of the northern area, proving that the climate became cooler in advancing northwards, as at the present time; for through the enormous expanse of continental land, the climate was much more equable than at present. There is, therefore, no reason to believe, from the absence of these plants, and of bones of long-armed apes present in the Miocene of Central Europe, that the Lower Miocene is absent in the Arctic zone; and from the determination by Prof. Heer, of Cretaceous forms in the Greenland deposits, it is probable that the continental conditions expressed by the Miocene of Europe and India, had commenced in these Polar regions as early as Cretaceous times. Should further discoveries of freshwater Cretaceous and Miocene deposits, lying in the hollows of the older rocks, be found in the northern lands visited by the British Arctic Expedition, it will be of great interest to see how far southern species die out in advancing to the present Pole, and what minimum of cold the surviving species appear to indicate.

The Esquimaux inhabitants of the coasts of Arctic America, from Behring's Straits to Greenland, speak the same language and use similar implements. There is no more interesting passage in Prof. Dawkins' work "Cave Hunting" than that in which he compares the identity of type of those implements with those from Dordogne and other parts of France and Belgium, both as regards fowling and fishing spears, darts and arrows. Their likeness extends to the actual shape of the base of insertion into the haft, the haft being formed of mammoth-ivory, derived from the frozen cliffs, of the very species that was hunted by paleolithic man in the south of France. These two peoples, separated so widely in time and space, were alike in their artistic feelings and methods of incising on tusks, antlers and bones, representations of familiar objects; alike also in their habits of splitting bones for marrow, and accumulating them around their dwellings, in their disregard for the sepulchre of their dead, in their preparation of skins for clothing, and in the pattern of the needles used in sewing them together; alike also in their feeding on the musk sheep and the reindeer, and in countless other characteristics. It is well-nigh impossible to resist Prof. Dawkins' conclusion that the Esquimaux is the descendant of palæolithic man, who retreated northwards with the Arctic fauna, with which he lived in Europe; though before the close of the Glacial Epoch it is probable that a continuous land connection existed between France and North America, by way of

Siberia; remains of the true horse having been discovered associated with *Bison priscus*, and the mammoth in Arctic America, and representations of the horse, by a palæolithic artist, occurring on an antler from La Madelaine, and the entire skeleton of a horse from a palæolithic station being preserved in the Lyons Museum.

VISIT TO THE MINERALOGICAL DEPARTMENT OF THE BRITISH MUSEUM.

MARCH 18TH, 1876.

Director—Professor N. S. MASKELYNE, F.R.S.

DEMONSTRATION ON THE FELDSPARS AND MICAS.

(*Report by* W. H. HUDLESTON, ESQ., M.A., F.G.S.)

The Feldspars are prominent in granitic districts, such as those of the Land's End, where prisms and square masses of orthoclase, or potash feldspar, are especially to be noted. In their crystallography, which the learned Professor declared to be the bane of chemists, although there are many points of contrast between orthoclase and the anorthic feldspars, they possess one feature in common, viz., an easy cleavage in one direction—the basal cleavage. The second system of cleavage is less perfect and presents fewer features in common, but taken altogether there is a certain correspondence with respect to cleavage and general form, though one individual feldspar belongs to the oblique, the rest to the anorthic system. Usually these two different systems are not comparable, but in extraordinary cases we may compare them, as practically some of the angles of the oblique are near to those of the anorthic feldspars. Thus in the oblique (orthoclase or potash) feldspar the angle between the easy and the second cleavage is a right angle, or 90°; whereas in the anorthic feldspars it is only 86½°: the prism angle, on the other hand, was shown in orthoclase, belonging to the oblique system, to be about 118°, and that of albite, belonging to the anorthic system to be about 122°. Still the two belong to essentially different orders of symmetry, and what was here shown of albite will apply to all the other anorthic feldspars.

As regards twinning, or multiplication of the crystal, the feldspars are acted upon in accordance with a certain law. In orthoclase a crystal may be divided symmetrically, and repeated, being turned round a certain line, as it were, completely through an angle of 180°. As a result of this law, in many instances a crystal is repeated as though reflected in a mirror. In this way we have both salient and re-entering angles, for it must not be supposed that grooves are necessarily anorthic, as ordinary feldspar has re-entering angles: hence we have striations parallel to the mutual intersections. In plagioclase, *i.e.*, in the anorthic feldspars, we have another kind of phenomenon: the twinning here is by thousands of crystals upon thousands of crystals, a fundamental turning of molecular arrangement. These alternate kinds are thus interlaminated, and this peculiarly polarized light serves to orientate. On the cleavage planes of a specimen of oligoclase exhibited, the reflection from successive ridges produced by this internal structure was shown to be one of the characteristics of plagioclase feldspar.

In their chemical composition the entire group are combinations of silica and alumina, the protoxide base varying with the kind of feldspar. In the oblique system we have orthoclase combined with potash; in the anorthic system, albite combined with soda, and anorthite (resembling albite, but smaller) combined with lime, and this contains the smallest amount of silica. Thus the feldspars divide themselves chemically—the potash feldspars are oblique or single orthoclastic; the soda feldspars, the lime feldspars and their mixtures, anorthic and plagioclastic. As a rule those which contain the most alkali contain also the greatest percentage of silica, and occur in rocks where silica is in excess. In the two great divisions of the Rocks, the *Acidic* and *Basic*, which are convenient as *memoria technica*, if not strictly philosophic, we find the alkaline feldspars, including also oligoclase, associated with quartz and hornblende, less frequently with augite. On the other hand, anorthite and labradorite are not found in regular granite. In trachyte, such as that of the Rhine, we have oligoclase associated with sanidin (a glassy orthoclastic feldspar). Labradorite is essentially the feldspar of the hypersthenites and gabbros, as also of basalt and phonolite; but it is not in all cases easy to determine the particular plagioclase feldspar. As regards oligoclase and labradorite, they have been regarded as intermediate varieties; and Tschermak considers that there are only three true feldspars, viz., orthoclase, albite, and anorthite, and that all others are mixtures of these.

THE MICAS.—These are rock-building minerals of great importance, especially in gneiss and mica schist, where they occur frequently associated with garnet. Devoid of any satisfactory chemical formula, the group has long been the bugbear of mineralogists. They are silicates, in which the protoxide base is chiefly an alkali or magnesia, never lime; those that occur in the feldspathic rocks are richer in alkali. Thus muscovite, or potash-mica, occurs in granite rocks, whilst biotite and phlogopite (fiery face), which have mostly crystallized from cooling lavas, are rich in magnesia. Still these different micas shade into one another, and it is difficult to say whether such are mixtures or not. In the Plutonic rocks, or those that have crystallized under pressure, the potash micas especially occur. They are sometimes the results of pseudomorphism, and often the first minerals that crystallize out of the changing mass; thus we see muscovite as the result of the decomposition of tourmaline. In the old lavas of Monte Somma there is an abundance of magnesia micas. The group seems to have the faculty of crystallizing with great ease, and the crystals were thus able to take up from the "stew" in which both steam and liquid carbonic acid are probably present, a variety of substances thus held in solution. This readiness to take up may possibly serve to explain their complex character.

The crystallization of the micas is more difficult to understand. They all have this feature in common, viz., that the crystals will split up like the leaves of a book into plates of extraordinary thinness, and polished, as it were, to the hand. What is the primary form? There are no traces of the lamellar character in the unaltered crystal. So difficult is it to decide to what system of crystallization the micas belong, that a particular specimen, to which the lecturer drew attention, had been referred to the hexagonal system by Vom Rath, and to the prismatic by Descloiseaux. The lecturer was disposed to concur with the latter. In biotite the angle is almost 120°, bringing it very nearly into another system. In muscovite, or old mica, the prism has an angle of nearly 120°, as in hornblende; and in this way it simulates an oblique mineral: thus in the specimen exhibited there seems to be two oblique faces, but these are really prismatic. Again in their optical characters, as displayed under the polarizing microscope, some micas—as, for instance, biotite—have been called uniaxial; but this is really because the axes in the so-called uniaxial micas are close together, yet there is a small space between them; and this, in conclusion, the learned lecturer proceeded to demonstrate by experiment.

VISIT TO THE MUSEUM OF THE GEOLOGICAL SOCIETY, BURLINGTON HOUSE; INSPECTION OF THE SOUTH-AFRICAN COLLECTION;

APRIL 1st, 1876.

Director—Professor T. RUPERT JONES, F.R.S.

(*Report by* PROFESSOR RUPERT JONES.)

Before offering any observations on the fossils and rock-specimens from South Africa in the Geological Society's Museum, Professor Rupert Jones drew the attention of the Members of the Association to several maps and sections of the country, some borrowed from the Society's library, and some brought by himself. The collection laid open before the audience comprised specimens obtained by numerous observers*—Basil Hall, Herschel, Bain, Atherstone, Rubidge, Garden, Sutherland, Grey, Rocke, Stow, Longlands, Harvey, and others, in various districts of the Cape Colony, and Natal.

The *slates and schists* of the south-western extremity of Africa were first referred to, and their intrusive *granite*. These schistose rocks extend northwards into Namaqualand, and eastward to George and the Eastern Province. No fossils have been detected in the schists of the maritime districts of George, Swellendam, Stellenbosch, Western Clanwilliam, and Namaqualand; but these are succeeded inland by fossiliferous schists, with Devonian fossils in abundance, especially in the Bokkevelde, and at intervals from the Warm Bokkeveld to the Zwartberg and the Kromme Hills, ending in Cape St. Francis, also in the Coxcomb Range of the Great Winterhoek in Uitenhage. Great folded quartzites and siliceous schists represent this formation in the Zuurberg of Somerset and Albany, and may be a development of the narrower band of siliceous schist at Ceres (accepting Rubidge's interpretation of the section) on the extreme west. Near Port Elizabeth, in Uitenhage, the quartzose strata, intercalated with the argillaceous beds, have resisted the process of cleavage, whilst their softer associates have been rendered schistose, with cleavage at various angles; and thus the broad folds and arches of quartzite, coming to the surface, have remained as a relatively flat, hard capping to the hills, which are mainly formed of more or less vertical schists. The original undulating lines of stratification in the latter are often obliterated by cleavage, the obscure oblique traces of fossils alone remaining as evidence of the real bedding.*

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* List of works treating of the Geology of South Africa are to be found in the Transact. Geol. Soc., Ser. 2, Vol. vii., pp. 176, 177; in Dr. E. Cohen's "Geological and Petrographical Sketches of South Africa," "Neues Jahrbuch für Mineralogie," &c., 1874, pp. 462, 463. Some other references are given with this Report; and other papers will be found in the "Geologist," Vol. iv., 1861, p. 238; Vol. v., 1862, pp. 47, 56, and 366; "Geological Magazine," Vol. ii., p. 274; iii., p. 88; v., pp. 201, 558; vi., p. 208; viii., p. 49; "Popular Science Review," Vol. x., p. 169; "Eastern Province Magazine," 1856, p. 7; "Eastern Province Monthly Magazine," Vol. i., p. 187, 456, 518, 580; "Cape Monthly Magazine," Vol. v., p. 65; *ib.*, Vol. vii., p. 1; Wyley's "Reports," 1856 and 1859; "Annales des Mines," Ser. 5, Vol. viii.; Dunn's "Notes on the Diamond-fields," 8vo., Cape Town, 1871; Quart. Journ. Geol. Soc., Vol. xi., pp. 1, 453, 465, 532, 541; xii., p. 237; xiii., p. 233; xv., p. 193, 195, 555, 642; xvi., p. 49; xxi., p. 439; xxiii., pp. 1, 139; xxv., p. 169; xxvi., p. 516; xxvii., pp. 35, 53, 497, 523; xxviii., pp. 3, 21, 28; xxx., pp. 54, 406, 581; xxxi, pp. 106, 529.

Fossil plants and coal accompany the Devonian Schists of the Cape Colony at Swellendam, Riversdale, and elsewhere, especially at the mouth of the Kowie in Albany. It is quite possible, in accordance with the late Dr. Rubidge's view, that the *whole* mass of schists forming this great southern portion of the region, 120 miles broad at the Cape, and 60 in the Eastern Province, where it is cut off by the sea, is of Devonian age. Whether the Kowie coal-beds belong to this Devonian series, or overlie it and belong to the Carboniferous, is not clear. At no other place along the northernmost edge of these Devonian schists are any coal-measures yet known.

Overlying the schists, throughout a great part of the region above indicated, are massive sandstones and quartzites, forming hills and mountain-ranges of great extent. Table Mountain, overlooking Cape Town, consists of this sandstone, resting on denuded schists and granite, and presenting a typical example of this flat-bedded rock, which once extended far north and east, but has been reduced to long narrow ranges by the destructive action of water, and possibly ice. No fossils have been found in this great sandstone formation in the Cape Colony; but Mr. Griesbach found a few obscure shells in a shale-bed of the "Table Mountain Sandstone" in Natal, where he recognised it as holding the same relative position with regard to the schists and granite below as it holds at the Cape.

Immediately north of the Devonian schists, and succeeding in geological sequence all along a line nearly parallel with the coast, and reaching at least from Clanwilliam (on the west), at about 100 miles inland, to the sea in the Eastern Province, near the Great Fish River, is a remarkable band of rock, which in most places has a veritable volcanic aspect, consisting of some kind of dioritic matrix, with included blocks and small fragments of quartz, granite, schist, and other rocks. This, the "Trap-breccia" of some geologists, attains a thickness of five, or even eight hundred feet. At places it appears to be a hardened trap-ash with numerous rounded and angular fragments of older rocks (Wyley). Mr. G. A. Bain regarded this rock as a "claystone-porphyry," from its local aspect. Amygdaloidal at some spots, and basaltic at others, where seen by Dr. Atherstone in the Cape Colony, it has quite a different appearance in Natal, where Dr. Sutherland and Mr. Griesbach have described it as a Boulder-clay. In the Eastern Province the late Dr. Rubidge looked on this rock as being metamorphic. Here it exhibits several parallel outcrops, which both Bain and Rubidge considered to be the result of great folds, conformable with the folding of the older quartzites of the Zuurberg. The latter (1,000 feet thick) are of Carboniferous age, according to Bain and Wyley, but Devonian if we follow Rubidge. The occurrence of real Boulder-beds in India under strata equivalent to the Karoo formation supports the hypothesis of the sedimentary origin of the South-African "Breccia;" but in some places of the latter country it may really present a decomposed condition of a trap-breccia, and thus only simulate a Boulder-clay; whilst at other places the disturbances that broke up the rocks, to make the breccia, may not have been accompanied by volcanic phenomena. Both below and above the trap-breccia are dark shales, with obscure plant-remains, the Lower (800 feet) and Upper (1,200 feet) "Ecca beds." The Lower set is supposed to be of Devonian or Carboniferous age; whilst the Breccia and the Upper Dark Shales are referred to the Karoo Series above.

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* A section of partially cleaved rocks in Pembrokeshire, illustrative of the relationship of nearly horizontal sandstone to nearly vertical schists, is given by De la Beche, in the "Memoirs of the Geological Survey of Great Britain," Vol. i., p. 226.

This vast KAROO FORMATION, next succeeding, is of great interest. It covers 200,000 square miles, and more, of South Africa, from N. lat. 35° northwards, and from E. long. 19 45° eastwards. These strata are horizontal (slightly inclined on their southern verge), and are traversed and overlain, but not much disturbed, by frequent trap-dykes. The lowest division of the Karoo formation, next above the Ecca Beds, comprises the "Koonap Beds" (1,500 feet), having a comparatively narrow outcrop north of, and parallel with, that of the Ecca Beds and the Breccia, and concentric therewith. Next are the "Beaufort Beds" (1,700 feet), on which stand both Beaufort West, north of Prince Albert, and Fort Beaufort on the east. The denudation of these horizontal Beaufort strata forms a very broad exposure north of and within the Koonap outcrop, and reach up to the Colesberg district. To the west and north of this, the lower series of Karoo shales and sandstones are more or less exposed, until they end against the old rocks of the Kalahari Desert and Griqualand-West (Stow); but on the east they are surmounted by the remnant of the uppermost or "Stormberg" portion (1,800 feet) of the Karoo series; and these, with their trap-rocks, form the top of the Drakensberg or Quathlamba range (11,000 feet), overlooking Natal, and resting, as a whole, on the primary rocks of that district.*

The Karoo formation consists mainly of alternations of shales and sandstones, at many places rich with reptilian remains,† and here and there yielding fossil fish allied to *Palæoniscus* and *Amblypterus* (*Hypterus*, Owen), a few Bivalves (*Iridina*, &c.), and a rare *Estheria*. Plant-remains (ferns and *Phyllothecæ ?*) and fossil wood are abundant in several beds, and there are some workable coal-seams in the Stormberg series.‡

In his elaborate "Catalogue of the Fossil Reptilia of South Africa in the British Museum" (4to, 1876), Professor Owen describes and illustrates the following (all, but one, from the Karoo formation):—

CLASS—REPTILIA.
Order—Dinosauria.
  Section—Tretospondylia.
    Genus—Tapinocephalus ; 1 species.
   Family—Serratidentia.
    Genus—Parieasaurus ; 2 species.
     „ Anthodon ; 1 sp. (Jurassic).

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* See Mr. Griesbach's Memoir on Natal, Quart. Journ. Geol. Soc., Vol. xxvii. p. 53, pl. 2.

† These fossils are often invested or permeated by very hard, tough rock, related to that of the trap-dykes; and in some cases they seem to have been derived from other beds, as they differ from the rocks in which they occur, and yet do not appear to be in concretionary nodules. —Dr. G. Grey.

‡ "Mining Journal," January 14, 1871. For the distribution of the Karoo fossils, as known up to 1867, see Quart. Journ. Geol. Soc., Vol. xxiii, pp. 142-144.

Order—Theriodontia.
    Family—Binarialia.
        Genus—Lycosaurus; 3 spp.
        „ Tigrisuchus; 1 sp.
    Family—Mononarialia.
        Genus—Cynodracon; 2 spp.
        „ Cynochampsa; 1 sp.
        „ Cynosuchus; 1 sp.
        „ Galesaurus; 1 sp.
        „ Nythosaurus; 1 sp.
        „ Scaloposaurus; 1 sp.
        „ Procolophon, 2 spp.
    Family—Tectinarialia.
        Genus—Gorgonops; 1 sp.
Order—Anomodontia.
    Family—Bidentalia.
        Genus—Dicynodon; 11 spp.
        „ Ptychognathus; 6 spp.
    Family—Cryptodontia.
        Genus—Oudenodon; 7 spp.
        „ Theriognathus; 1 sp.
        „ Kistecephalus; 7 spp.
    Family—Endothiodontia.
        Genus—Endothiodon; 1 sp.
SUB-CLASS—DIPNOA.
Order—Labyrinthodontia.
    Section—Æquidenticulata.
        Family—Coccoganoidea.
            Genus—Petrophryne; 1 sp. (qy., the same as *Micropholis*, Huxley, Quart. Journ. Geol. Soc., Vol. xv., p. 654, pl. 21.)
            „ Saurosternon, Huxley; 2 spp. (Lacertian, according to Huxley, "Geological Magazine," Vol. v., p. 201, pl. 11.)

Professor Owen has also noticed, in former years, vertebral indications of fossil Reptiles from the Karoo formation, which he designated *Massospondylus*, *Pachyspondylus*, and *Leptospondylus* (Quart. Journ. Geol. Soc., Vol. xvi., p. 62).

Professor Huxley has described a species of *Dicynodon* *

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* Quart. Journ. Geol. Soc., Vol. xv., p. 649, pl. 23.

(*Ptychognathus?*); remains of two large Dinosaurians[*] (***Euskelesaurus*** and *Orosaurus*); a serratident, ***Pristerodon***;[†] and his lacertilian *Saurosternon* and batrachian ***Micropholis*** (see above). All of these are also from the Karoo formation.

The only evidence of marine life among the fossils of the Karoo formation is one fragment of an encrinite[‡] in a calcareous breccia from the Rhenosterberg, a spur of the Sneeuwbergen (Quart. Journ. Geol. Soc., Vol. xv., p. 194). This may have been derived from older Devonian beds.

The probable lacustrine character of the Karoo formation has been dwelt upon by Bain and others; and the existing analogy of wide expanses of fresh water in Central Africa has been pointed out by Murchison and Livingstone. The probably vast extent of land in early Mesozoic, if not in late Palæozoic, times, but since destroyed, has been ably treated of by Huxley, Blanford, and others, in explication of the occurrence of wide-spread terrestrial conditions during the Permio-Triassic ages in different parts of the world.

Elsewhere in Cape Colony, especially on the Sunday, Zwartkop, and Gamtoos Rivers, there are JURASSIC strata, known as the "Uitenhage Formation;"[§] and these groups appear to have been deposited in great hollows or seas of the period, quite disconnected from the older "Karoo formation." They opened out eastward; and on the west they rested against the old Primary rocks, which formed, and still form, the great south-eastern boundary of that terrestrial and lacustrine area.

An underlying conglomerate ("Enon") and a remarkable series of plant-bearing beds ("Wood-bed," &c.) belong to this series.

Traces of similar Jurassic rocks are known higher up the coast, near the Zambesi, and far down on the south and west in the George district.

Some similar, but less extensive, patches of CRETACEOUS strata occur on the Natal coast; and these also have lost, by denudation, their connection with far greater deposits, continuous, probably, with the old Indian and West-Asiatic Cretaceous seas, and associated with the "Lemurian" lands of the past.

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[*] Quart. Journ. Geol. Soc., Vol. xxiii., p. 1.

[†] "Geological Magazine," Vol. v., p. 204, pl. 12.

[‡] This specimen, in the Geological Society's Museum, was specially pointed out.

[§] See Mr. Tate's Memoir on South-African Fossils, with Notes by T. Rupert Jones, Quart. Journ. Geol. Soc., Vol. xxiii., p. 149.

TERTIARY, or rather POST-TERTIARY deposits, succeed in the Eastern Province; and, whether in isolated patches or over broad areas, on the Primary or on the Secondary rocks, they were formed on the eastern slopes of the country, facing the Indian Ocean, and were continuous with its floor previous to some of the latest alterations of level, which have raised them above the sea-level.

The *Alluvial* flats near the Cape and further inland present, as usual, varied evidences of atmospheric agencies in having arranged mud, sand, pebbles, lignite, &c., by gentle or by violent means. The great sandy flats of the interior, and the shingle and boulders of the river-valleys, all indicate enormous lapse of time and effectual work of Nature's every-day forces; and even the results of glacial action have been demonstrated by Mr. G. W. Stow (Quart. Journ. Geol. Soc., 1871, Vol. xxvii., p. 544, &c.) in these subequatorial regions.

Some remarks were offered, in conclusion, on the conditions under which diamonds are found in South Africa, both in the valley-gravels and in the diggings on and near certain old trap-dykes, which have traversed the Karoo shales. A visitor, who had lately returned from the Cape, exhibited a quantity of small diamonds which he had obtained, and kindly replied to enquiries made by the Associates. Professor Tennant made some remarks on the quantity and size of the South-African diamonds.

Professor Morris, after some instructive remarks, tendered the thanks of the Members to Professor Rupert Jones for his interesting lecture, and expressed the obligations of the visitors to the President and Council of the Geological Society for their courtesy in opening their Museum on this occasion.

Mr. B. B. Woodward, Assistant Curator of the Museum, has kindly furnished the following notes:—

In illustration of Prof. Rupert Jones' remarks, the original large MS. map of South Africa, geologically coloured by Mr. A. G. Bain, and a large series of South-African rocks and fossils were exhibited. The latter included specimens from the Tertiary deposits of Algoa Bay; Jurassic fossils from the Sunday and Zwartkop Rivers; and plant-remains from the Jurassic "Wood-bed," at Geelhoutboom, Sunday River; trilobites, encrinites, spirifers, and other Devonian fossils from the Warm and Cold Bokkevelds, north of Cape Town; rock-specimens from the diamond-fields; jaspers from the ranges of the Potgieter's and Rooi Kopjes;

and reptilian bones, ammonites, and other Cretaceous fossils from the coast of Natal.

This South-African collection is composed of the donations that have been from time to time made to the Society by travellers and residents; among others, Mr. A. G. Bain, Dr. Atherstone, Dr. Rubidge, Captains Garden and Rocke, and Mr. Stow, men whose names will always be associated with South-African geology. Many of the specimens contained in it are unique, and many have been described and figured in the Society's publications.

The Members of the Association also inspected an interesting series of rock-specimens (jaspers, quartz, chalcedony, &c.), and silicified woods and corals from Antigua, which were exhibited in illustration of a paper that had been read before the Association a short time before, by Prof. Rupert Jones.

Amongst the many objects of interest in the possession of the Geological Society, an original MS. geological map of England, by William Smith, "the Father of English Geology," and the MS. table of strata by the same renowned pioneer of the science, attracted perhaps the greatest attention.

ORDINARY MEETING, April 7th, 1876.

William Carruthers, Esq., F.R.S., &c., President, in the Chair.

The following Donations were announced :—

"The History of Rutherglen and East Kilbride," by David Ure; from the President, William Carruthers, Esq., F.R.S.

"Geological Map of Ireland," from the President, William Carruthers, Esq., F.R.S.

"The Geology of Camberwell," by Arthur Bott, F.G.S.; from the Author.

"List of Works on the Geology of Hertfordshire," by W. Whitaker, B.A., F.G.S.; from the Author.

"Notes on the Geology of the North Midlands," by W. J. Harrison, F.G.S.; from the Author.

"Description of Sopwith's Geological Models," by F. Sopwith, F.R.S.; from Professor James Tennant, F.G.S., &c.

"Notes on the Geology of the Coast of Labrador," by Oscar M. Lieber ; from John Hopkinson, Esq., F.L.S., &c.

"Report of the United States Geological Survey of the Territories," Vol. ii. "The Vertebrata of the Cretaceous Formations," by E. D. Cope; from Dr. F. V. Hayden.

"Bulletin of the United States Geological and Geographical Survey of the Territories," No. 6, Second Series; from Dr. F. V. Hayden.

"Abstracts of the Proceedings of the Geological Society," Nos. 315 and 316; from that Society.

"Journal of the Society of Arts," March, 1876; from that Society.

"Transactions of the Manchester Geological Society," Vol. xiv, Part 2; from that Society.

"Transactions of the Watford Natural History Society," Vol. i, Part 3; from that Society.

"Proceedings of the South Wales Institute of Engineers," Vol. ix, No. 4; from that Institute.

"Proceedings of the Warwickshire Naturalists' and Archæologists' Field Club," 1875; from that Club.

The following were elected Members of the Association:—

Alfred K. Huntington, Esq., Memb. Phys. Soc.; the Rev. Robert Johnson; and H. Wolfram, Esq.

The following Paper was read:—

ON THE VOLCANOES OF ICELAND, WITH SPECIAL REFERENCE TO MOUNTAINS WHICH HAVE RECENTLY ERUPTED.

By WILLIAM LORD WATTS, Esq.

EXCURSION TO GRANTHAM AND NOTTINGHAM.

EASTER MONDAY, APRIL 17, 1876, AND FOLLOWING DAY.

Directors—THE REV. ALEXANDER IRVING, B.A., B.Sc., F.G.S., and W. H. HOLLOWAY, ESQ., F.G.S., H.M. Geological Survey.

(*Report by* THE REV. MR. IRVING.)

The Directors, chosen for their special knowledge of the geology of this part of the country, were W. H. Holloway, Esq., F.G.S., one of the officers of Her Majesty's Survey, at present employed in the district about Grantham and Newark; and the

Rev. A. Irving, F.G.S., who is known in Nottingham from his former connection with the High School. The programme was a somewhat extensive one, and moreover time had to be allowed for the journey of the major portion of the party from London on Monday morning. It included the examination of sections in the various formations lying within easy reach of Nottingham, which range from the Lincolnshire Limestone (Inferior Oolite) downwards to the Coal Measures.

On the way by train from Peterborough to Great Ponton, glimpses were obtained of most of the Lower Oolite series. At the former place the Cornbrash is seen in the bank at the side of the station premises, and its exposure extends thence nearly two miles along the line towards Essendine. At the Casewick cutting is a freshwater gravelly deposit, containing freshwater shells and fossils derived from the Oxford Clay. The Cornbrash is seen at the bottom of the cutting, and again in the Banthorpe cutting. On leaving Essendine Station the Great Oolite limestone is seen overlying the clays of the Upper Estuarine series. In the Dane's Hill cutting a slight synclinal curvature of the strata has exposed:—

1. Cornbrash (a little on the top near the north end).
2. Great Oolite Clay.
3. Great Oolite Limestone (two very hard distinct bands).
4. Upper Estuarine Series.
5. Inferior (Lincolnshire) Oolite, reached at the south end.

From this place to Little Bytham, cuttings occur in Lincolnshire Oolite, with clays of the Upper Estuarine series occasionally overlying it; and from thence to Corby these ferruginous sands, with frequent false-bedding, are very well exposed in a number of cuttings. From Corby to Great Ponton we have first a small cutting in the Great Oolite limestone; next a long cutting through Boulder Clay; then (leading to the tunnel) a cutting in which numerous blocks of limestone are seen jutting out of the Boulder Clay. On leaving the tunnel the Boulder Clay is still seen resting on the eroded surface of the limestone not far from Ponton.

Work with the hammer commenced in the Great Ponton cutting, where the train from London arrived at twelve o'clock on Monday. Here the party was joined by the local conductor from Grantham, and Mr. Holloway gave a short lecture on the nature and fossil contents of the strata (of which about 30 feet are exposed at this spot), embodying the chief results of the labours of Professor Morris and others in the district, some twenty-five years ago. The beds exposed belong to the upper part of the Lincolnshire Oolites. The section may be roughly represented by the following tabulated statement :—

1.—Rubbly Oolite	5 feet.
2.—Eight to ten beds of Shelly Oolite (in some parts soft), very fossiliferous, with five zones of *Terebratula* and *Lima*, in various stages of growth ...	15 feet.
3.—Soft Marl, containing Oysters in abundance at the north end, dividing and becoming thinly laminated towards the south	4 in. to 1 foot.
4.—Marly Rock, with Corals, *Nerinæa* and *Turbo*, somewhat irregular	2 feet.
5.—Coarse Shelly Oolite and Freestone...	15 feet.

Owing to the recent widening of the cutting, unusual facilities were offered for examining this section and procuring fossils, and after plying the hammer vigorously for half an hour or so, the party proceeded to another section in the same formation, which has been formed by the Little Ponton cutting. The courtesy of the Great Northern Railway Company deserves special acknowledgment here. Not only did they respond promptly to the request made by the Secretary for permission to work upon their line at these two spots, but to ensure the party against accidents from trains they generously gave the Association the services of one of their own officers, whose special knowledge of the traffic relieved the Directors of the Excursion from some anxiety and responsibility. At Little Ponton, the cutting is much deeper than that at Great Ponton, and (the strata lying in both cases nearly horizontally) a greater range of beds is exposed. At the former place, too, they are much thicker than at the latter, more massively bedded, but much more sparsely fossiliferous. They are much disturbed and broken in one or two places, the numerous fissures resulting from this being, in many cases, lined with stalagmite and other forms of carbonate of lime. The nature of the beds examined in this section may be seen from the following (in descending order) :—

1.—Rubbly Oolite composed of "Rag" and very comminuted Shelly Beds, with compact Shelly Beds, some "pisolitic"	15 feet.
2.—Thin band of Slaty Clay	2 to 3 inches.

3.—Compact Marly and Shelly Rock, with *Lucina*, *Pinna*, *Ostrea*, *Trichites*, and Corals	5 feet.
4.—Marly Oolitic Rock, containing *Gervillia acuta*	5½ feet.
5.—Compact Marly Rock, with few Oolitic grains	1 foot.
6.—Thin bed of Clay	2 to 3 inches.
7.—Coarse-grained Oolitic Rock	6 feet.
8.—Stratified Grey Sandy Clay	1½ feet.
9.—Marly Oolite full of small Pectens	½ foot.
10.—Compact Marly and Sandy Rock, with *Gervillia acuta* and *Trigonia Phillipsii*	3½ feet.
11.—Ferruginous Sandy Oolite, with shells in fragments, forming the base of the series known as Lincolnshire Limestone	1 foot.

This fine section, replete as it is with stratigraphical interest, furnished few complete specimens, owing to the broken and comminuted condition of its organic remains. The above sections were furnished by Mr. Holloway.

The Members having regained their carriages, made for Grantham. Before passing over the railway to the south of this town, they drove along an elevated tract of country, formed by the ferruginous beds of the sands which mark the passage from the Upper Lias clays to the Inferior Oolite. These beds may be seen in the cutting to the south of the bridge, capping the dark blue clays of the Upper Lias. They correspond with the lower series of the Northampton Sands, which have been very extensively worked of late years for iron ore. From the investigations of Samuel Sharp, Esq., F.G.S., of Northampton, it appears that the Lincolnshire Limestones lie between two such series of ferruginous sands of estuarine origin; and that the thinning-out of the limestone about Oundle allows the upper and lower series to coalesce, and so form the thick deposit of ferruginous ore which has made the country about Kettering and Wellingborough famous. From Grantham the route lay through Harlaxton and Denton to Croxton. On the way a fine view was obtained of the Lincolnshire "Cliff" (a worn-down escarpment of Lincolnshire Oolite), and two interesting road-sections were obtained—the first exhibiting the junction between marlstone and clays of the Middle Lias series; the second the passage from the Upper Lias clays into the ferruginous sands described above. One incidental feature of this Easter excursion was the quantity of drifted snow through which the carriages had to pass, from the heavy downfall of the previous Thursday.

At Croxton the party was met by W. Ingram, Esq., of the Duke of Rutland's estate, who pointed out various features of the surrounding country (including some remarkable terraces in the valley of the Devon) as the route was continued towards Belvoir Castle, where, through the liberality of his Grace the Duke of Rutland, the lovers of geology were to be regaled with a sumptuous luncheon. To this justice was soon done under the presidency of W. Green, Esq., the Duke's agent, and a cordial vote of thanks having been passed to his Grace, the party, refreshed and invigorated, proceeded—some to view the interior of the castle, others to see the magnificent gardens and rock-work. Bidding adieu to these lofty towers, the party arrived, after about an hour's drive, at Elton Station. The night was fast closing in by this time, and therefore a very imperfect examination only could be made of the Rhætic Beds which are exposed here, and of the gypsum quarries which are worked in the uppermost beds of the Keuper series. So the first day ended by the party taking the train to Nottingham, and being soon snugly housed at the George Hotel.

The SECOND DAY (Tuesday) was well-occupied. Leaving Nottingham by the 9.30 train in the morning, paying a visit on the way to the Nottingham Natural History Museum, which had been opened for the purpose through the kindness of the Mayor and the Museum Committee, the extensive stone-quarries in the neighbourhood of Mansfield were visited. The stone quarried hereabouts is not a pure dolomite or magnesian limestone, but consists of an admixture of (roughly speaking) about 45 per cent. of carbonate of lime and magnesia, with from 1 to 3 per cent. of oxide of iron, and about 50 per cent. of silica. Hammers were freely called into play, and specimens procured of both the white and the red varieties of "Mansfield stone." As good fortune would have it, the progress of the works at the quarries belonging to R. C. Lindley, Esq., of Eastwood (who had readily granted access to the Members of the Association) had necessitated the removal of the Upper Permian Marls which overlie the Magnesian Limestone, and the Members present had a good opportunity of viewing the uneven and eroded surface upon which these marls were deposited. After visiting Mansfield Woodhouse, and spending some time in examining the purer beds of dolomite which are quarried in that locality, and afford great facilities for studying "irregular bedding" and "oblique lamination" on an unusually large scale, the party found its way back to the Swan Hotel, at Mansfield. Taking the train for Bulwell, they made their nearest way to Cinder Hill. In the brick-yards belonging to C. Seeley, Esq., the Upper Permian Marls which had been examined at Mansfield were again recognised, resting, as in the former instance, upon the Magnesian Limestone strata. The marls are succeeded (in ascending order) by rather hard deep-red sandstones, considered by the geological surveyors to be the highest member of the Permian System; a group of strata which some geologists prefer (on a more complete review of the evidence) to consider as "Lower New Red Sandstone." There is no unconformity apparent between the highest bed of the "Permian" and the lowest bed of the Triassic series (Bunter) at Cinder Hill; the only line of demarcation is a band of brecciated materials which varies in thickness from a few inches to about three feet. The breccia contains a variety of fragments, the greater number consisting of sub-angular pieces of limestone, much altered by the action of water, and somewhat dolomitic in character. They appear, however, to be derived, not from the Magnesian, but from the Carboniferous Limestone, since many of them contain undoubted fragments of encrinites; and in the same breccia at Kimberley such fragments are even more frequently met with. This being so, there remains no evidence to be drawn from this breccia-bed, of any very great period of time having elapsed between its deposition and that of the Permian strata beneath it, to which it belongs just as much as to the Bunter above, passing as it does in some places underneath the uppermost layers of the sandstones of the Upper Permian. In the examination of this section much valuable assistance was obtained from E. Wilson, Esq., F.G.S., of Nottingham, who has done good work in the Permian and Triassic strata of the district, and to whose well-drawn sections the members of the party were much indebted. Much interest was added to the study of this section, and of the faults by which it is intersected, by a short lecture on the ground from George Fowler, Esq., F.G.S., the mining-engineer of the collieries, who gave a clear and perfect explanation of the effect of the faults upon the Coal Measures underneath the Permian at this place, and by the diagrams by which this was illustrated. The Magnesian Limestone is here faulted up against the Upper Permian and Bunter strata, and while these two formations are equally affected by the fault, the Coal Measures below them have been proved by actual measurement to be dislocated by some 60 yards of vertical displacement more than the two series which here crop out at the surface. The enormous lapse of time which must be postulated to allow for 60 yards of displacement by the slow sliding of the strata against one another on opposite sides of the fault, before the Permian strata were deposited upon their denuded surface, is recorded also at Kimberley, where the base of the Permian System is now exposed in two new railway sections resting unconformably upon the planed-off edges of Coal Measure shales and sandstone. Much interest appeared to be aroused by the evidence which the brickyard sections and those in the railway cutting not far distant afforded of the close relation that exists between the so-called Permian strata and those of the Bunter above them, the conclusions inferrible from the examination of them in this district being very different from those which we draw from the perusal of ordinary text-books of the science, and tabulated statements published by persons in authority. A walk from Cinder Hill along the new railway afforded opportunities for further study of the Bunter and so called Permian strata, and in the cuttings which form the approaches to the tunnel at Watnall magnificent sections were obtained. Here and near Kimberley, on the new Midland line, the Magnesian Limestone and Marl Slate series may be studied with unusual facility at present. They rest upon a base of exceedingly hard calcareous breccia, which forms the base of the Permians over a large district in Nottinghamshire. Very compact in texture, this breccia varies in thickness from one to three feet; and throughout the calcareous matrix numerous small angular fragments are dispersed, the origin of which cannot be easily determined. Small cavities, too, are of frequent occurrence, lined, in some instances, with calcite; in others with iron pyrites. Above it about twenty-five feet of Marl Slate occur, in which Mr. Wilson has found casts of *Axinus;* below it the Coal Measure clays and shales, containing nodules of hæmatite, dip to the north-east, with an unconformity of about 15 degrees.

A walk of about three miles brought the party to Ilkeston, where the train was taken for Nottingham and London.

EXCURSION TO BROMLEY, SUNDRIDGE, AND CHISLEHURST.—April 22nd, 1876.

Director—J. Logan Lobley, Esq., F.G.S.

(*Report by* Mr. Lobley.)

A large area in the neighbourhood of Bromley is occupied by the Shell-beds and the overlying Sands and Pebble-beds of the Lower Eocene, and good sections of these beds are exposed along the railway in the vicinity of Bromley Station. In the cutting to the east of the station, to which the party at once proceeded, the Shell-beds, the estuarine deposits of the Woolwich and Reading Series, are seen inclined at a low angle, dipping to the west. The characteristic *Cyrena cunieformis* occurs here in great abundance, associated with *Ostrea*. At the western end of this cutting the Sands form the upper beds exposed. So large was the party, and so frequent were the trains, that it was deemed unsafe to remain long on the line, but sufficient time was spent to enable all to note the character of the beds, and to obtain specimens of the shells which so distinctly indicate the estuarine character of these deposits.

The Pebble-beds are well seen immediately behind the railway station, by the side of the inclined road which has been cut through them. These remarkable beds, an accumulation of shingle, are, with the underlying sands, the equivalents in the western part of Kent of the beds exposed at Oldhaven Gap, near the Reculvers, and called by Mr. Whitaker, the "Oldhaven Beds." They consist of smooth, oval, blue-black flint pebbles, with, in some places, a considerable quantity of intermingled sand, and in others, as at Plumstead, a matrix of carbonate of lime which cements the pebbles together, forming a conglomeratic rock; and in other localities, as at Blackheath, the pebbles are almost devoid of any intermingled material. As has been pointed out by Mr. Whitaker, the entire absence of subangular or little-worn pebbles indicates that this vast bed of worn Chalk flints was not a shore accumulation of shingle at the foot of a Chalk cliff, like that now forming the beach at Brighton, but was doubtless a shoal or bank considerably removed from the shore line, to which pebbles would only reach after much rolling and consequent wear. The bed of quartzose sand, usually found underlying the Pebble-beds, Mr. Whitaker considers ought to be associated with them, and not with the Woolwich Beds proper. The "Oldhaven Sand" occurs at this section, with a most irregular upper boundary, the Pebble-beds entering the Sands in wedge-like or teeth-like masses to a considerable depth. This section shows a remarkable instance of current bedding, the oval pebbles lying with their longer axes horizontal, while, as has been pointed out by Mr. Whitaker, lines of bedding, inclined at an angle of 25°, are very distinct. This is, perhaps, even better seen at a new section of the same beds on the opposite side of the railway, which was next inspected.

A walk through the village of Bromley brought the party to the grounds of Bromley Palace, the residence of the late Mr. Coles Child, F.G.S., who was one of the Directors of the Excursion of the Association to Bromley in 1872. (See "Proceedings of the Geogists' Association," Vol. iii, p. 114.) A small section of the Woolwich Beds here, when not masked by overgrowth, shows a *Cyrena*-bed distinctly separated by a stratum of clay from an *Ostrea*-bed. Springs of highly ferruginous water are seen in one or two places in the grounds, and an ancient bath-house attests the value set upon this water in past times.

After walking through the beautiful grounds of Bromley Palace, in which are some of the largest evergreens in the neighbourhood of London, the party proceeded by the path across the fields to Widmore Kiln, passing at a little distance the nearest hop-garden to the metropolis. The section at Widmore is figured in the "Geology of the London Basin," page 246, and on page 247 is described as follows: —

	Soil.	Feet.
LONDON CLAY.	Grey and brown weathered Clay, at most	8½
	Basement bed: Clayey Pebble-bed, the pebbles of black flint	¼ to ½
OLDHAVEN BEDS—	Light-coloured (mostly nearly white) sand, with a few pebbles in the upper part, chiefly in one broken line, and a few thin clay-layers; below 8 feet from the top of these last are in force... ...	12 or more.
OLDHAVEN (or WOOLWICH) BEDS?	Dark bluish-grey clay, laminated, with a few very thin sandy layers, small pieces of leaves, wood (in the state of lignite) and iron pyrites ... ...about	9
	Sand, with layers of clay in fine alternations. At one part (in the trough) the top highly ferruginous; at another it seems to pass up into the clay, the lower part of which is then more sandy. Tabular concretionary masses of sandstone occur a few feet down, and still lower many good impressions of leaves have been found. Not bottomed. ...	26 or more.

The "Dark bluish-grey clay" is probably peculiar to this section, Mr. Whitaker stating that he is unaware of any other place at which it is seen. A collection of well-preserved specimens of leaves from the Widmore beds was in the possession of Mr. Coles Child in 1872, but now plant remains are rarely found. The President, Mr. Carruthers, F.R.S., determined the leaves found here to belong to the sub-tropical *Ficus* and *Cinamomum*, genera, it is worthy of remark, not represented in the London Clay of Sheppy, which contains a large flora of a tropical and sub-tropical character.

The various beds having been pointed out and described, the way was led to Sundridge Park, and through its glades to the woods at the eastern extremity, in which is situate the "Rock-pit," so well known to Lower Tertiary geologists. The Sundridge "rock" is a conglomerate of shells and smooth oval flint pebbles, embedded in a calcareo-argillaceous matrix, and affords rough building stones well adapted for rustic buildings, to which its variegated surface adds picturesqueness, as is exemplified by the Chislehurst Lodge of Sundridge Park. This deposit seems to combine all the characters of the Woolwich Beds, both lithological and palæontological, since it is at once a shell-bed and a pebble-bed, contains much argillaceous, much siliceous, and much calcareous matter; and it yields both the estuarine and the fluviatile species which characterise the Woolwich Beds in various areas. In a very short time *Ostrea pulchra*, *Pectunculus Plumsteadii*, *Cyrena cuneiformis*, *C. deperdita*, *Cerithium funatum*, and *Melania inquinata* were found.

Leaving with reluctance this attractive quarry the party continued the prescribed route, and emerging from the park entered one of the pretty and secluded valleys which give so much beauty to this part of Kent. At no great distance to the east of Sundridge Park a section shows Chalk with overlying Thanet Sands, thus revealing the Chalk "inlier," which extends from west to east for upwards of three miles, surrounded by the Lower Eocene. Of this inlier, Mr. Whitaker writes at page 65 of "The Geology of the London Basin :"—"The valley that runs through Sundridge, Camden, and Bickley Parks, between Bromley and Chislehurst, lays bare an outcrop of this formation (Thanet Sands), and the Chalk, in the form of an inlier, that is to say, surrounded on all sides by a higher formation. This exposure of the Thanet Sands, within the area of the overlying Woolwich Beds, and at so high a level, is owing to a slight upheaval of the beds, which has brought the lower formation within reach of the common forces of denudation ; the outcrop extends from the north-western part of Sundridge Park, through Camden and Bickley Parks."

The line of the Sevenoaks railway was then crossed, and on its northern side an exposure of Thanet Sands, Woolwich Beds, and Oldhaven Beds was found in a recently formed road. The section having a sloping face, the pebbles which have rolled down from the uppermost bed cover a considerable portion of the surface, and thus the Pebble-bed appears to be much thicker than it is, and the Sands correspondingly less important than is really the case.

Still going eastward the party were next conducted to the entrance to the Chalk Caves of Camden Park. Lower beds than any previously seen during the day are exposed here, the Chalk being revealed to a depth of from 15 to 16 feet. The usual bed of green-coated flints separates the Chalk from the Thanet Sands above, which extend to the soil at the top of the section. The Chalk at this place, obviously the uppermost bed of the Chalk of West Kent, appears to be harder and more compact than the similar bed at other sections. One bed, not much below the top, is so continuous and compact that it forms an immense unjointed slab, constituting a continuous roof to the caves, or rather galleries, which extend for a long distance under Camden Park. These galleries, driven under ground for quarrying purposes, consist of longitudinal and transverse workings, leaving great masses as pillars for the support of the roof. Sponges are more than usually abundant in the Chalk of this place, and some good specimens were obtained on this occasion.

In the fine work by M. Charles Barrois, a Member of the Association, "Recherches sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irlande," just published, the various beds named in the classification of the Chalk of this part of England by another of our Associates, Mr. Caleb Evans,* have been correlated with the divisions of the Chalk generally which M. Barrois seeks to establish. This correlation is given at page 139 as follows :—

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* "On Some Sections of the Chalk between Croydon and Oxted," by Caleb Evans, F.G.S.

CLASSIFICATION OF THE CHALK of the South-East of England, by Mr. Caleb Evans.	GENERAL CLASSIFICATION OF THE UPPER CRETACEOUS, by M. Barrois.
	Assise à Belemnitelles.
Purley Beds.	Zone à Marsupites.
Upper Kenley Beds.	Zone à M. coranguinum.
	Zone à M. cortestudinarium.
Lower Kenley Beds.	Zone à Holaster planus.
Whiteleaf Beds.	Zone à Terebratulina gracilis.
Upper Marden Park Beds.	Zone à Inoceramus labiatus.
Lower Marden Park Beds.	Zone à Belemnites plenus.
	Zone à Holaster subglobosus.
	Chloritic Marl.
	Zone à Pecten asper.
	Zone à Ammonites inflatus.

It will thus be seen that M. Barrois considers the highest Chalk in this part of England to be the second of his divisions, "Zone à Marsupites;" and at page 138 we find it stated—" C'est dans cette région (Kent) que les zones à *Holaster subglobosus* et *Belemnites plenus* acquièrent leur plus complet développement. La zone à Belemnitelles n'est pas connue dans cette partie de l'Angleterre."

Exposures of all the beds from the Upper Chalk to the London Clay had now been seen. It remained to ascend to the high ground of Camden Park, which affords extensive views over the district, and a good stand point from which to note the physical features of this part of Kent. Much of the picturesque beauty of the neighbourhood is doubtless due, as Mr. Whitaker shows, to the occurrence as the uppermost formation of the Oldhaven Pebble-beds, which, being easily disintegrated, are cut through in many places, forming numerous small valleys with steep slopes. The well-wooded vales and hills of East Kent, from their varied geological structure, support a diversified vegetation with timber of large growth, the beech, the elm, the oak, and the yew often attaining great dimensions. Passing to the south of Camden Place, the chosen retreat of Napoleon III, the common, and the village of Chislehurst were at length reached, when a general desire for rest and refreshment induced the party to linger awhile before leaving by train for London.

EXCURSION TO THE GORGE OF THE MEDWAY, AND KIT'S COTY HOUSE.—MONDAY, MAY 1ST, 1876.

Director—Professor JOHN MORRIS, F.G.S.

(*Report by* W. H. HUDLESTON, ESQ., M.A., F.G.S.)

The party from London, after proceeding by the North Kent line, entered the valley of the Medway at Stroud, opposite Rochester. From this point the Maidstone branch of the railway is carried up the remarkable gorge in the Chalk, through which the waters of a large portion of the Weald find their way into the sea. This is one of the four great breaks which traverse the North Downs. At Snodland, which is situated upon the Gault, the funnel-shaped entrance to this gorge, on the escarpment side, is very apparent.

Here the party descended from the train and crossed the Medway towards Burham, where there are extensive quarries in the Lower Chalk. These yielded several interesting fossils, and amongst others true coprolites, often mistaken for conical fruits. Some of the members thence ascended towards the Middle Chalk of Blue Bell Hill, where, under the guidance of Mr. Johnson, they found several ventriculites. The bulk of the party followed Professor Morris along the road at the base of the escarpment. This road crosses a country much covered by grey-wethers. Four immense stones of this kind, relics of the Lower Tertiaries, constitute the remarkable monument known as Kit's Coty House, said to be the finest cromlech in the south-east of England. It is situated towards the middle of the Chalk escarpment, and commands a complete view up the valley of the Medway in the direction of Maidstone. Here the Director took the opportunity of delivering an instructive address upon the subject of the denudation of the Weald, and the formation of these remarkable gorges, at the entrance of one of which the party was then standing.

"Looking at the controversy which had long been waged between the rival champions of marine and sub-aerial denudation, he considered that it must be admitted that the latter had, in a great measure, proved their case, and that in point of fact a considerable portion of the clays of the longitudinal valleys of the Weald had been removed in the course of ages and carried down through these gorges, which were themselves the result of erosion of the harder beds, acting in all probability upon lines of weak resistance, and partly also determined by an alteration in the strike. Therefore the scooping out of the great longitudinal valleys, as well as the erosion of the transverse valleys, must be in a great part due to rain and rivers, which have been acting ever since the rise of the old Wealden dome. The Quaternary beds of the Medway Valley are of the highest interest, and extremely fossiliferous, but are the most extensively developed and contain the greatest quantity of remains in the funnel-shaped mouths of the gorges such as this at Aylesford, and also in the same valley above Maidstone, where there is an analogous break in the Lower Greensand escarpment. At such places there seems to have been a great spreading out of the waters, arising from a choke in the narrows during times of flood. This gave rise to temporary lakes, into which the carcases of animals were floated. At present Aylesford is only about 38 feet above the sea level, and yet there seems to be evidence that the Medway flowed at a far higher level during a period when the neighbouring fauna was much the same as when the elephant-gravels of the Aylesford pits were formed. For in the heights above Maidstone, gravels occur at elevations of 300 feet, containing nearly the same kind of bones as those of the lower terraces. The inference is that the Medway has done much excavating work during the period which elapsed between the deposition of these high-level gravels near Maidstone and the low-lying ones of Aylesford."

Early in the afternoon the party lunched at Aylesford, in company with Mr. Bensted, and several gentlemen from Maidstone and the vicinity. They then adjourned to the gravel-pit, where a most striking section is exposed. At the base is 20 feet of almost pure white sand, the bleached and incoherent beds of the Folkestone-series of the Lower Greensand. On this reposes a splendid series of mammaliferous gravel and sand, bearing evidence of much erosion, hollowing out, and redeposition by current action; indications of ice action also are noticeable. Though three-fourths of the recognizable pebbles and stones consist of Chalk flints, there were noted boulders of the Folkestone-beds, huge masses of Kentish Rag, and other fragments of Lower Greensand, with *Gryphœa sinuata*, and—most interesting of all—a few well-rounded fragments of Wealden (Hastings) rock with *Cyclas*. The presence of these latter was held to indicate that the direction of the pebble-transporting currents must have been from south to north, or in the same direction as that in which the river now flows, and may be deemed to supply evidence against those who consider the bell-mouthed entrance of the Medway gorge a proof of the old river having discharged itself in a southerly direction. Many teeth of *Elephas* were secured by Members, together with other prizes, and the whole party had the satisfaction of seeing an immense curved tusk, not less than 10 feet in length, which formed a prominent feature in the face of the section. This glory of the old Pleistocene world gradually yielded to repeated blows of the pick-axe, and most of the Members thus secured a souvenir of the great pit at Aylesford. Two fine teeth of *Rhinoceros* were also found.*

The next place visited was the brickyard, where about 50 feet of Gault and Chalk Marl were visible. At the time of the visit the base of the working was about on a level with the *Ammonites varicosus* zone of Folkestone, and the following were some of the fossils noted :—*Belemnites minimus*, List.; *Nautilus* sp.; *Hamites* sp.; *Ammonites varicosus*, Sow.; *A. lautus*, Sow. (var.); *A. inflatus*, D'Orb.; *A. splendens*, Sow. (perhaps derived); *Alaria Orbignyana*, Pict. et Roux.; *Dentalium decussatum* Sow.; *Inoceramus sulcatus*, Park, *I. concentricus*, Park; *Nucula pectinata*, Sow.; *Pentacrinus Fittoni*, Aust.; *Trochosmilia sulcata*, Edw. and Haime. The upper portion is less fossiliferous, and is succeeded by Chalk Marl with very little intervening Upper Greensand.†

This Chalk Marl, which forms the top of the excavation, was observed to be sliding forwards down the face of the quarry in a sort of viscous condition, and with its surface crevassed exactly like that of a glacier.

Notices of this district are to be found in the "Proceedings of the Geologists' Association," Vol. i., page 63; Vol. iii., page 38, *et seq.*

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* A depth of nearly 20 feet of gravel is here seen resting on the sands of the Folkestone Beds. It is false-bedded with sand, fine gravel, and loam. Many bones have been found here, chiefly *Rhinoceros* and *Elephas primigenius*. Mr. Boyd Dawkins identifies one of the specimens from this place as *Elephas antiquus*, Falc. This fossil has been recorded from no other locality within the Weald. The terrace to which the Aylesford gravel belongs spreads in a continuous sheet from the Burham Gault pits to near Cob Tree.—"Memoir on the Weald," p. 174.

† The pits at Aylesford and Burham give some of the best sections of the Gault in the interior; usual thickness, 100—120ft., as at Snodland. About 18 inches of "greenish grey marly sand," with dark grains, phosphatic nodules, and cream-coloured concretions are interposed between the top of the Gault and the Chalk Marl.—"Memoir on the Weald," pp. 47 and 153.

ORDINARY MEETING, MAY 5TH, 1876.

Professor J. MORRIS, F.G.S., &c., Vice-President, in the Chair.

The following Donations were announced:—

"Twenty-second Annual Report and Abstract of Proceedings of the Brighton and Sussex Natural History Society, 1875;" from that Society.

"Journal of the Society of Arts," April, 1876; from that Society.

"Bulletin of the United States Geological and Geographical Survey of the Territories," Vol. ii, No. 2; from Dr. F. V. Hayden.

"The Philosophy of Geology," by David Page; from the President, William Carruthers, Esq., F.R.S.

"Chips and Chapters, a Book for Amateur and Young Geologists," by David Page; from the President, William Carruthers, Esq., F.R.S.

The following were elected Members of the Association:—

The Rev. J. L. Knowles; J. Campbell Oman, Esq.; Tudor Rogers, Esq.; and Thomas D. Russell, Esq.

The following Papers were read:—

1. ON THE SECTION OF THE CHLORITIC MARL AND UPPER GREENSAND ON THE NORTHERN SIDE OF SWANAGE BAY, DORSET.

By H. GEORGE FORDHAM, Esq., F.G.S.

At the stage to which geological knowledge has now attained, I believe that students of geology, who have but a limited time at their disposal, will best further the interests of the science by the careful examination of some of the many undescribed, or but little known sections, and by placing on record their observations. The facts thus obtained will, in course of time, by their accumulation and comparison, lead to a valuable increase in our knowledge of the state of the earth in the past. Such work is the most suited to members of an Association like this; and if it could be systematically pursued by a number of our Members, the results would soon become of importance.

With this idea, I beg to place before the Association an account of a section which exhibits the Chalk Marl, Chloritic Marl, Upper Greensand and Gault, and is situated on the northern side of Swanage Bay. It will be found on Sheet 16 of the Geological Survey Maps on the one-inch scale.

The section, which has a general direction of about E. and W., and is about half a mile in length, is somewhat irregular, and is, in places, much obscured by débris. The beds dip at the eastern extremity of the section, 58° N.N.E., and towards the centre 60° in the same direction, and their strike is therefore E.S.E. and W.N.W., which approaches rather nearly to the direction of the face of the section. The irregularity and obscurity of the latter combined with the dip of the beds, make it rather difficult to obtain accuracy in estimating the thickness and order of the different divisions. The débris has been mostly formed by the fall of the Upper Chalk beds from the high cliffs, and in view of the possibility that future falls may cover up the whole or a great part of the section, it is desirable that the succession of the beds and their characteristics should be registered.

In passing along the shore from Ballard Hole to Punfield Cove, the whole series of beds from the "Chalk Rock" to the Gault is seen, either in the cliffs or on the shore; except a small break (caused by a large mass of fallen chalk) in the Chalk Marl.

The "Chalk Rock," which seems to succeed very closely the lower beds of the Chalk with flints, rests on solid White Chalk without flints, and this is followed by the Chalk Marl, or Grey Chalk; but as none of these beds, except the latter, are easily accessible without a boat, I did not examine them closely, and merely mention them by way of introduction to the succeeding strata. The point at which my notes commence is where a thick slightly-bluish bed, composed to a great extent of a branching sponge, a species of *Brachiolites*, is seen on the shore. Below this is a series of hard and soft alternating beds, the harder generally containing more or less of the *Brachiolites*, and having at its base two sandy beds with phosphatic nodules; this extends nearly down to the Chloritic Marl, being separated from it by about 30 to 40 feet of similar beds, but without *Brachiolites*. The total thickness from this uppermost *Brachiolites*-bed to the top of the Chloritic Marl I have estimated at from 130 to 140 feet.

Mr. Whitaker, in a paper, "On the Chalk of the Southern Part of Dorset and Devon,"* in writing of this section, says :—" The Chalk Marl has a thick grey bed at top, and seems to be about 60 feet thick. It is succeeded by hard, bedded Chalk without flints, which again is soon succeeded by a thin layer of the Chalk Rock," —from this it would appear as if my " Upper *Brachiolites*-bed " is the same as Mr. Whitaker's "thick grey bed," and may be taken as the top of the Chalk Marl; if this is the case it will give to that deposit a much greater thickness than Mr. Whitaker supposes it to have.

Messrs. Conybeare and Phillips have alluded to this section in their " Outlines of the Geology of England and Wales," at page 85, as follows :—

> " At Handfast Point, on the coast of Dorsetshire, the flinty Chalk is 600 feet thick, and that without 200 feet, but the peculiar position of this stratum at this place should make us cautious of relying on any estimate of its thickness, unless we are told in what manner it has been taken."

I should prefer to call the beds below the phosphatic beds Chalk Marl, and those above, characterized by the presence of *Brachiolites*, Grey Chalk. As, however, I have no palæontological evidence to offer (except the fact of the persistence of the *Brachiolites* through the Grey Chalk), other fossils being generally scarce, I do not wish to consider my divisions other than temporary.

This series of *Brachiolites*-beds (Grey Chalk) has a thickness of about 100 feet, and has, at its base, as I have stated above, two beds of phosphatic nodules; below the lowest of these are about 30 to 40 (?) feet of white and bluish-white solid marly chalk (Chalk Marl), and this passes into the Chloritic Marl, a bluish marly clay, with glauconitic grains, small quartz grains and phosphatic nodules, four feet thick, resting on the Upper Greensand.

The Upper Greensand is from 65 to 70, or perhaps 75 feet in thickness, and consists of light yellowish-green sandy beds in its upper part, and bluish-green clayey beds in its lower part; it also contains many beds of concretionary stones, like the beds in the Isle of Wight, and nodules of phosphate of lime and of pyrites.

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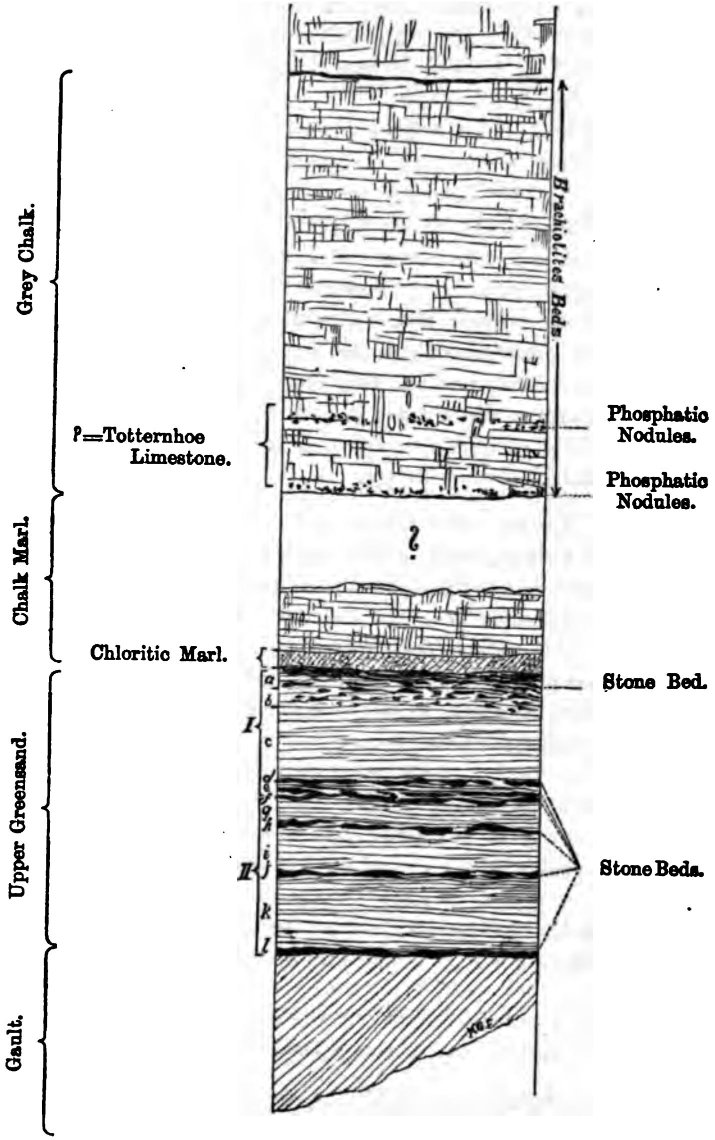
* Quart. Journ. Geol. Soc., Vol. xxvii, p. 93.

GENERAL SECTION.

Scale 48ft. = 1 inch.



The phosphatic nodules, which often take the form of casts of shells, etc., are generally of a brownish, rotten material; but occasionally a hard black phosphate occurs; neither kind is very abundant, the former being more prevalent in the lower and more clayey beds. Many of the fossils in the upper part of the Greensand are very fragile, and the majority of them are unmineralized, and never adhere to or contain phosphate.

The Gault is seen on the shore towards the western end of the section near Punfield Cove, and has about 25 to 35 feet exposed amongst the boulders forming the beach; the bed which I have taken as the base of the Upper Greensand is here seen as a thick layer of bluish stone resting on the Gault. The Gault is a bluish-green sandy clay, very dark (almost black) when wet, but weathering to a lighter colour; it contains no phosphatic nodules, and fossils are not common. There are, however, a few fossils which seem to occur in little groups; they are very fragile. In Punfield Cove itself, only a slight trace of the upper part of the Upper Greensand is observable, the other beds are entirely covered up by fallen material and vegetation.

I.—GREY CHALK, 103 feet.

Alternate beds of bluish clayey marl, and harder, whiter beds; the latter often in great part made up of *Brachiolites*. A few small nodules of pyrites are scattered about in the lower beds. At the top are two well marked *Brachiolites*-beds. About 84 feet from the top the beds become yellowish, and slightly sandy, with streaks of lighter marl; a bed of scattered, small, light-coloured phosphatic nodules is here present.

A few feet further down, at about 97 feet from the top, there are a few small nodules of pyrites.

From the 99th to the 103rd foot is a dense *Brachiolites*-bed, containing dark ramified masses and a few nodules of pyrites and phosphate; this rests on a more clayey and darker bed. This last *Brachiolites*-bed becomes, in some places, more phosphatic and lighter, forming a second Phosphatic Nodule bed.

FOSSILS FROM THE PHOSPHATE BEDS.

Nautilus elegans, (?) *Sow.* b. p.
Ammonites navicularis, *Sow.*
Ostrea vesicularis, *Sow.*
Plicatula pectinoides, *Sow.*
Terebratula ovata (?) *Sow.*
„ large sp.
Serpula antiquata, *Sow.*
Discoidea subuculus, *Klein.*

II.—CHALK MARL, 40? feet.

[The section is here obscured by fallen masses, the portion hidden being estimated at about 20 feet.]

The lower 20 feet consists of compact white beds, alternating with clayey, bluish fissile beds, and contain no phosphatic nodules or *Brachiolites;* no fossils apparent in the small surface exposed. This passes down into the Chloritic Marl.

III.—CHLORITIC MARL, 4 feet. Characteristic fossil *Rhynchonella Mantelliana, Sow.*

The upper foot of this contains a little glauconite and phosphate, and may be taken as the passage bed into the Chalk Marl above. The remaining three feet are a bluish clayey marl, with streaks and markings of a lighter colour, and are sometimes stained with oxide of iron. This bed has small nodules of phosphate, and much glauconite, mixed with quartz grains.* Its junction with the underlying Upper Greensand is irregular but *well marked.*

FOSSILS.

Otodus appendiculatus, *Ag.*
Nautilus, sp.
Ammonites rostratus, *Sow.* b. p.
„ varians, *Sow.*
Scaphites simplex, var. Hugardianus, *D'Orb.*
Ostrea vesicularis ? *Sow.*
Pecten quadricostatus, *Sow.*
Cardita ? sp. b. p.
Terebratula biplicata, *Sow.*
„ semiglobosa, *Sow.*
„ sp. ? b. p.
Rhynchonella lineolata, *Phill.*
„ Mantelliana, *Sow.*
Cidaris, spine.
Serpula, sp.
„ sp.

IV.—UPPER GREENSAND, about 70 feet.

a. A rough stony bed, formed of masses of concretions (weathering to a rounded rough surface) in a light-green glauconitic sand; it contains many specimens of *Pecten asper*, *Pecten orbicularis*, *Exogyra vesiculosa*, etc., with but few phosphatic nodules. 5 to 6 feet. Characteristic fossils, *Pecten asper*, *Pecten orbicularis*, *Exogyra vesiculosa* and *Terebratella pectita.*

FOSSILS.

Ammonites splendens, *Sow.* bn. p.
Pecten asper, *Sow.*
„ orbicularis, *Sow.*
Pecten quadricostatus, *Sow.*
„ interstriatus (?), *Leym.*
Exogyra conica, *Sow.* var. undata.

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* When digested with dilute hydrochloric acid and washed, the residuum consists of about equal quantities of small, white, rounded quartz grains and green glauconite grains.

Exogyra vesiculosa.
„ haliotoidea, ? *Sow.*
Ostrea canaliculata, *D'Orb.*
Cucullæa glabra, *Park.* bn. p.
Terebratella pectita, *Sow.*
Vermicularia concava, *Sow.*

b. A soft, light-coloured green sand, with a few scattered concretions like those in the bed above. 4 feet. Characteristic fossil, *Exogyra columba.*

FOSSILS.

Pecten, sp.
Panopæa plicata, *Sow.* bn. p.
Exogyra columba, *Sow.*
Ostrea vesicularis (?), *Sow.* b. p.
Trigonia, sp. b. p.
Vermicularia concava, *Sow.*
Serpula, sp.

c. Much like *b*, but without concretion, and containing a few small nodules of pyrites and small, broken, rotten, brownish phosphatic nodules, and also broken fragments of shells and many *Vermicularia.* It is very friable. 17 feet.

FOSSILS.

Ammonites rostratus, *Sow.*
Pecten interstriatus (?), *Leym.*
„ quadricostatus, (?) *Sow.*
Ostrea vesicularis (?), *Sow.*
Exogyra columba, *Sow.*
Exogyra haliotoidea, *Sow.*
Cidaris (spine).
Vermicularia concava, *Sow.*
Serpula annulata, *Dixon.*
„ sp.

d. Stone-bed:—Solid concretions, in places forming a continuous band. Coloured reddish with oxide of iron. 0 to 1½ feet.

e. Soft, darkish greensand with *Vermicularia*, etc., like *c.* 1 to 2 feet.

f. Two irregular stone beds with sand between. They sometimes coalesce and form one bed. 1 to 2½ feet.

FOSSIL.

Rhynchonella compressa, *Lam.* b. p.

g. Like *c*, but becoming more clayey and bluish. 4 to 6½ feet.

h. Stone bed, like *d.* 1 to 2½ feet.

FOSSILS.

Pecten quadricostatus, *Sow.* b. p.
„ interstriatus (?), *Leym.*
Exogyra conica, *Sow.*
Ostrea vesicularis (?), *Sow.*
Ostrea canaliculata, *D'Orb.*
Cucullæa glabra, *Park.* bn. & b. p.
Trigonia, sp. b.p.
Panopæa plicata, *Sow.* b. p.
Vermicularia concava, *Sow.*

i. Bluish sandy clay. 6 to 14 feet.

FOSSIL.

Vermicularia concava, *Sow.*

j. Stone bed; very continuous, and weathering to a light-blue with white veins. 1½ feet.

FOSSILS.

Ammonites rostratus, *Sow.*
Pecten orbicularis, *Sow.*
Cucullæa glabra, *Park.* b. p.
Arca Mailleana (?), *D'Orb.* bn. p.
Vermicularia concava, *Sow.*

k. Like *i.* 17½ feet.

FOSSILS.

Dentalium decussatum, *Sow.* b. p.
Arca (Cucullæa) carinata, *Sow.* b. p.
Thetis Sowerbii, Röm. bn. p.
Exogyra, sp. ?
Ostrea, sp. ?
Trigonia, sp. b. p.
Vermicularia, sp.

l. Like *j.* Resting on Gault. 2 feet.

FOSSILS.

Plicatula inflata, *Sow.*
Pecten quadricostatus, *Sow.*

V.—GAULT.

The fossils above enumerated are those which I obtained from the beds during a few days' work, and probably represent only the more common species. Those which occur as casts in dark-coloured or black phosphate are distinguished by the letters b. p. after them; those in light-brown phosphate by the letters bn. p. The remainder are found without phosphate being in any way attached to them.

The whole series of beds from the top of the Chalk to the Gault is fairly continuous, the only slight break being between the Chloritic Marl and the Upper Greensand. The latter, in its lower beds, becomes clayey, and shows a passage into the Gault; it may be roughly divided into two parts. The Upper, down to the bottom of bed *f*, being a light green soft sand, with the majority of its fossils unphosphatic; this is about thirty feet thick. The Lower division is of a darker colour, and more clayey material, and most of its fossils are in the form of phosphatic casts, usually broken, and without their shells. This is about thirty-seven to forty feet thick.

In the preceding I have used the term "Chloritic Marl," to signify the lowest bed of the Chalk Marl, which is characterised by the presence of glauconitic grains and phosphatic nodules, and a Chalk Marl fauna, mixed with many derived phosphatic casts of fossils. This bed may be traced along the whole of the sections of the beds of this horizon on the south coast of England from Eastbourne to Beer Head,* and is always seen resting upon what I consider the true Upper Greensand; it is represented in Cambridgeshire by the well-known Phosphatic Nodule (or "Coprolite") bed. At Eastbourne it is four to five feet thick, passing upwards into the Chalk Marl, and downwards into a homogeneous, unfossiliferous Greensand; in the Isle of Wight, at Culver Cliff, it is represented (?) by a clayey band about one foot nine inches thick, resting on the Upper Greensand with a pretty clear line of junction, and passing up into a sandy marl with a few scattered nodules of phosphate of lime, and it is "about five feet thick on the edge of the cliff at St. Catherine's Down."† At Beer Head and in the adjacent sections it is probably represented by Mr. Mĕyer's bed No. 13,‡ which is described by him as "Greyish or brownish chalk, with green grains, quartz grains, and *phosphatic nodules.* Thickness variable: four feet at White Cliff, five feet at Beer Head, four feet at Weston Mouth, two-and-a-half feet at Dunscomb." § On the preceding page he writes of the bed below. "The top of this bed (No. 12) presents an uneven surface at its junction with the next above, the junction of the two being also marked in places by a ferruginous line."‖

The slight line of unconformability (if it may be called so), between this Chloritic Marl and the underlying Upper Greensand I consider to be important, marking as it does a change from arenaceous to calcareous conditions, and being followed by a bed containing such strong evidence, in its derived fossils, of a widespread, although probably not very long-continued, denuding action. I do not wish it to be assumed that I consider this a zone of great change; it is one of minor importance if regarded from a large stratigraphical standpoint, but in connection with the smaller divisions of the Cretaceous rocks, it is from its persistence over large areas very valuable.

Another point worth notice in this section is the presence of two sandy beds with phosphatic nodules in the Grey Chalk or Chalk Marl. These beds bear so much resemblance to the Totternhoe Limestone, and their position is so nearly the same that they may be provisionally referred to that horizon. The Totternhoe Limestone is described by Mr. Whitaker* as follows:—"The stone in question is a rather sandy limestone, harder and darker than common chalk, containing many very small dark grains, and generally a few small hard dark-brown nodules (coprolitic?) and fossils. There are often two beds, of no great thickness (three or four feet), separated by a few feet of marl. . . . . The Totternhoe stone has been traced . . . from near Henton, at the eastern edge of Oxfordshire to near Hitchin in Hertfordshire, and its occurrence has been noticed farther north-east" (p. 39). On the preceding page (p. 38), Mr. Whitaker writes:—"The said stone really forms the top of the Chalk Marl, and is about eighty feet above the true Upper Greensand." It is much to be regretted that the Memoir does not contain any list of fossils from this bed. It will be noticed that the resemblance between the above-described beds and the Phosphatic beds at Swanage is very close.

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* "On the Cretaceous Rocks of Beer Head and the adjacent Cliff-sections, etc.," by C. J. A. Mĕyer, F.G.S., Quart. Journ. Geol. Soc., Vol. xxx, p. 369.

† "Memoirs of the Geological Survey of Great Britain. The Geology of the Isle of Wight." by H. W. Bristow, F.G.S., p. 25.

‡ "On the Cretaceous Rocks of Beer Head, etc.," by C. J. A. Mĕyer, F.G.S., Quart. Journ. Geol. Soc., Vol. xxx, p. 377.

§ Ibid, p. 377.

‖ Ibid. p. 376.

On reference to Mr. Mëyer's valuable paper on the Beer Head and neighbouring sections,† the similarity between the lithological and palæontological divisions observable in the Lower Cretaceous rocks in that locality and at Swanage, will be observed. A brief comparison, and, as far as possible, correlation of the beds at Swanage with the typical section as given by Mr. Mëyer for the Beer Head district may be useful. I must first observe that I differ (and it is with great diffidence that I venture to differ from so high an authority) from Mr. Mëyer in the use of the term "Chloritic Marl." Mr. Mëyer has identified with (in his words), "the so-called 'Chloritic Marl' of the Isle of Wight," his beds 10, 11, and 12, which I believe represent the beds in the Swanage section, which I have called *a* and *b* (and perhaps part of *c*), belonging to the true Upper Greensand. I have already stated that I consider Mr. Mëyer's bed, No. 13, and my "Chloritic Marl" are the same bed, and form the base of the Chalk Marl.

There is but little doubt, I think, that in the Swanage section, the beds, *a* (characterised by ***Pecten asper***, ***P. orbicularis***, ***Exogyra vesiculosa***, and ***Terebratella pectita***), and *b* (characterised by ***Exogyra columba***), are the equivalents of beds 12, 11 and 10, of Mr. Mëyer's section; my beds *c* to *g*, then probably represent Mr. Mëyer's beds 9 to 5; and the remainder of the beds which I have considered as Upper Greensand would then be equivalent to beds 4 to 2 in the Beer Head district. There certainly does not seem to be any of the true Gault (as seen at Swanage and in the Isle of Wight) in the Beer Head district; and if any of the beds there are to be correlated with the Gault, a perfect passage exists there between the equivalents of the Gault and Upper Greensand. In my Swanage Bay section I have placed the base line of the Upper Greensand below the lowest stone-bed (*l*), and have considered these concretionary layers characteristic of the Greensand; but there is no very strong ground for doing this, and the whole of the lower part of the section might be considered as Gault. I think, however, that the character and appearance of the rock (as compared with undoubted Gault at Swanage) is in favour of placing the line where I have placed it, the beds below being a decided clay, and the manner of preservation of the fossils being more like the typical Gault.

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* "Memoirs of the Geological Survey," Vol. iv, Part I, pp. 38 and 39.

† Quart. Journ. Geol. Soc., Vol. xxx, p. 369.

If I am right in drawing the base line of my Upper Greensand below my bed *l*, it would probably follow that the base of the Upper Greensand at Beer Head ought to be placed somewhere in bed 2, or lower. In fact my impression is that the Gault is not represented at Beer Head, and that the Upper Greensand there rests directly on various older rocks. It is indeed quite reasonable to suppose that in the gradual thinning out which has taken place in the Lower Cretaceous deposits in passing towards the west, and in the increase of littoral conditions, the lower beds should thin out first, for the higher we get the more oceanic become the deposits.

In concluding these few remarks, which I hope may be fortunate enough to arouse discussion on some of the points raised, I must express my thanks to Mr. A. J. Jukes-Browne for his kindness in looking over some of my fossils.

2. Notes on the Kimmeridge Clay of the Isle of Purbeck.

By W. R. Brodie, Esq.

(*Abstract.*)

The Kimmeridge Clay commences below St. Alban's Head, where it is overlaid by Portland Oolite and Purbeck Limestone. Beds of a grey-coloured limestone containing marine shells, oysters, and ammonites, immediately underlie the Portland Beds. These may be the Upper Passage-beds or the uppermost beds of the Kimmeridge Clay shales. They continue from St. Alban's Head through Chapman's Pool, and extend towards Encombe Park. They are lost sight of inland, but reappear on Gadcliff several miles to the westward.

At Chapman's Pool, in paper-shales, the following fossils have been obtained:—Jaws of small saurians, belemnites large and small, *Coccoteuthis latipinnis*, Owen, several species of squids, and marine shells.

Eastward of Encombe Park occur remains of fish and Crustacea in black pyritous shales, which give an offensive odour. At Encombe Point we find *Pliosaurus grandis*, spine of *Hybodus*, and other fish remains, cuttle fishes, and ammonites. In black oolitic shales, at the same locality, in beds running out to sea, jaws of reptiles and fish differing from those found at other points, Saurian vertebræ, three species of *Pterodactyle* resembling those from the Dorsetshire Lias, zoophytes and fruits.

Three or four miles to the westward is Kimmeridge Bay, where the paper-shales and the black bituminous shales are again met with. Not very far from Gadcliff, at the termination of the outcrop of the Kimmeridge Clay, *Coccoteuthis latipinnis*, figured and described by Professor Owen, was first discovered by the author, who also claims to have first found remains of cuttle fish in the Oolites of that part of England. At this place there have been found a jaw with teeth of a crocodilian reptile (in the thin shale beds), operculum associated with ammonites, reptilian bone described by Owen (Pal. Soc. Vol. for 1875), several species of ammonites, and fossil wood.

At Bucknowle, south-west of Corfe Castle, we find black earth with pottery, human bone, and flint implements, covering a thin seam of loam, which reposes on a deposit containing stones from a distance, flint implements, burnt wood, &c. The flints in the lowermost deposit are of the largest form, and differ much from those in the uppermost bed. Land, freshwater, and marine shells occur, along with remains of deer, ox, bear, lion, and fox. A limestone implement has also been found. Remains of elephant, deer, and ox have been found in gravel in Encombe Park. North of this locality a section shows the presence of the following beds:—

Middle Chalk, with flints.
Upper Greensand.
Gault, with fossils.
Lower Greensand, with fossils.
Wealden Beds.
Upper Purbeck or Middle Wealden.
Marble beds, with freshwater turtles, *Cypris*, and *Unio*.

EXCURSION TO HATFIELD.—May 13, 1876.

Director—John Hopkinson, Esq., F.L.S., F.G.S., Hon. Sec. Watford Natural History Society.

(*Report by* Mr. Hopkinson.)

On this occasion the Association for the second time met the Watford Natural History Society and Hertfordshire Field Club, the members of which arrived at Hatfield mostly by special train from St. Albans, and at the place of meeting, the principal entrance to Hatfield Park, the two societies were represented by a party of about 130 ladies and gentlemen. Permission to see over Hatfield House, and to visit the Hatfield Park Kiln, had been kindly granted by the noble owner, the Marquis of Salisbury.

The house, which was first visited, is necessarily more of historical than geological interest. It is built on the site of the palace of Bishop Morton, which was erected about the end of the fifteenth century, and of which a fragment still remains; and on its site again, from the commencement of the twelfth century, an episcopal residence had existed. The present mansion was commenced in 1607, and the materials used in its construction by its builder and architect, Robert Cecil, Earl of Salisbury, consisted chiefly of Caen stone, with stone from Tattenhall, Worksop, and the Northamptonshire quarries, and bricks and flints from the old palace which had fallen into decay.

After spending a considerable time in the house and grounds, the party proceeded across the park to the brick-fields, noticing on the way Queen Elizabeth's favourite oak, under which she was sitting when the news was brought to her that she was Queen of England, and the fine less-decayed oaks and other trees for which this park is so justly famed.

In the pits here, the Upper Chalk, and all the beds present at the northern outcrop of the London Tertiaries, are exposed, and areoverlaid by the High-level Gravel of Post-Pliocene age, the outline of which is well defined by the moistness of the surface of the ground around it. The section was described and compared with the sections of the same beds seen in the neighbourhood of Watford and elsewhere, both north and south of the Thames. A description of the section has, however, previously appeared in the Proceedings of the Association (Vol. iii, page 241) in Mr. Lobley's report of an excursion to Hatfield in 1873, to which report reference should also be made for information on the geology of the immediate neighbourhood.

In the basement bed of the London Clay a few fossils were collected, and the members of the two societies then returned to Hatfield across the park in detached parties, and thence, after partaking of tea at the Salisbury Arms, to their respective destinations—London, Watford, and various parts of Hertfordshire—by rail or road, having spent a very enjoyable afternoon in one of the most beautiful, and, for its historical associations, the most interesting park in the county of Hertford.

EXCURSION TO READING.—June 3rd, 1876.

Director—Professor T. Rupert Jones, F.R.S., &c.

(*Report by* W. H. Hudleston, Esq., M.A., F.G.S.)

The particular group of sands and clays which immediately overlies the Chalk of this district, has received the name of the "Woolwich and Reading Beds" from the fact of its being largely developed, and also, what is quite as important, perhaps, largely worked for economic purposes, in the neighbourhood of those two towns. These beds represent a low, though not quite the lowest, group of English Tertiary formations, and as there are no Tertiary beds at Reading itself lower in the series. they may be looked upon, in this area, as the base of the London Tertiaries. In this neighbourhood organic remains are scanty, scarcely any shells but oysters being found, and these mostly confined to one bed. In this respect the Reading representatives of the group differ considerably from the beds at Woolwich referred to the same geological horizon.

The party proceeded at once to Katesgrove Pit, on the further side of the Kennet, where the Messrs. Poulton kindly admitted Members to inspect this large excavation, which has been opened for at least 100 years. After a brisk discussion as to the origin of the name, which Mr. Albery had reason to believe was originally "Cattle's Grove," a very curious *amphora* was shown to the party. Mr. Poulton pointed out where the Roman relics were found on Bob's Mount, and the Director then led the way into the body of the excavation, which presents a fine section of the Reading Beds, somewhat impaired by landslips, but yet exhibiting in most striking contrast, the deep purple of the mottled clays, and the very pale buff of the underlying sands. A portion of the very base of the London Clay may be observed in one part of the section, succeeded by a variable deposit made up of re-arranged drift and sand, with occasional quartzites, the whole being covered by an ancient soil full of split flints. Captain Cooper King soon detected several of artificial origin, in which the bulb of percussion was well exhibited. Before quitting this pit the Director drew attention to the singular effects which may be noted in a pool, having a clayey bottom, in process of drying-up. In the first place he pointed out the tendency of the spaces included between the cracks, to assume definite geometrical figures, and, secondly, the curious reticulated markings in slight relief which cross these spaces, and which he showed to be due to the mole-like workings of a small beetle, a specimen of which was secured.

A little further on is the Waterloo Pit, where an interesting observation was made. In the loose white sands, which here constitute the most accessible portion of the Woolwich and Reading Beds, two irregular bands of paleish laminated clay or loam, generally about two feet apart, were observed, and portions of one, if not both of these, were largely charged with leaves of dicotyledonous plants, and notably of species of maple and poplar. These fossil leaves, already known to Mr. Albury, serve in a remarkable degree to establish the correlation between the Woolwich and Reading Beds, referred to this group, and are interesting to botanists as one of the earliest instances of *dicotyledonous* plants occurring in the British Islands. Such leaves had been found fossil within a mile or two of Reading by Mr. Prestwich, but were not generally known to occur so close to the town.

The party now crossed the valley of the Kennet, and proceeded to visit the pits in Coley-hill, both of which were most kindly thrown open to their inspection by the proprietors, Messrs. Wheeler and Messrs. Collier. The foreman of Messrs. Wheeler's pit, in anticipation of the visit, had requested the workmen to preserve any objects of interest, and, in consequence, a fine assortment of oysters and of sharks' teeth awaited inspection. The base of the formation, not seen by the party upon the other side in either of the pits hitherto visited, was finely displayed in Wheeler's pit, where a fresh piece had been cut out, exhibiting the entire series down to the Chalk on which it rests. Here the Chalk presents a level floor, and is much fissured and perforated to the depth of about 18 inches below its junction with the Woolwich and Reading Beds. These fissures are filled in with the material of the Bottom-bed, which consists largely of glauconitic grains, clay, and flint grit; pieces of lydite also occur. The partial decomposition of the iron of the glauconite has discoloured the sides of these fissures, which would seem, from certain appearances noted, to be the result of the roots of marine plants, which, having no loose stones to cling to, must have either forced their supports into the little chinks of the sea bottom, or be washed away. On this singular surface rests the Bottom-bed, which is a strange mixture of glauconitic grains, clay, subangular green flints, and small flint chips. Here occur the sharks' teeth and the oysters, the latter having a strong resemblance to those of our British seas, although known to palæontologists as *Ostrea bellovacina.* The oysters occur principally in a bed about 3ft. above the Chalk; but this oyster-bed, though of wide extent, is not proved everywhere throughout the workings on Coley Hill. Above this very curious "Bottom-bed," which seems to be a mixture of almost everything, and is thoroughly marine in its character, occurs a mass of buff-coloured sands with occasional blue shales, containing much carbonaceous matter, the upper portion being variegated buff and grey sands: these are surmounted by bedded clays of various colours, in which purple predominates—a curious formation, not known to contain any fossils. It seems to be made up of masses of other clays, all pugged together, and is possibly derived from the destruction of the outcrop of some "Secondary" clay, as it was slowly raised within the influences of marine denudation during the earth-movements which must have taken place in the area now occupied by the Thames Basin subsequently to the deposition of the Chalk. The top of these clays in Wheeler's pit, instead of being capped by London Clay, as at Katesgrove, has its surface, otherwise level, worn into a perfect network of holes and caldrons, which are filled in by the superincumbent gravel and remanié drift. The effect is most curious to the eye, and when one reflects upon the enormous interval of time which this singular line of erosion represents—an interval of time greater perhaps than that between the top of the Chalk and the base of the series—it must be admitted that a section may be almost as remarkable for what it leaves to the imagination as for what it actually offers to view. In Collier's pit, on the north side of Coley Hill, although the same general subdivisions prevail, there is sufficient variety to prove the very irregular character of these so-called estuarine beds. The especial object of search here were the "clay-galls" which occur in some of the sandy beds. When Professor Rupert Jones and Captain King drew the sections submitted to the Geological Society these clay-galls were abundant; yet such is the incredulous nature of geologists that considerable doubts as to these galls began to be entertained from the at first apparent difficulty of finding any. The Director, therefore, and his able coadjutor, Captain King, were by no means sorry when a considerable number of these remarkable balls of clay were before long found in the sands. Their explanation seems a very good one, namely, that during the deposit of this variable series a channel had been cut through a recently formed clay, such channel being flanked by little cliffs of the eroded clay. Sand was subsequently deposited in the erosion, and pieces of clay falling out of the little cliff from time to time were rolled into balls, sometimes including a flint pebble, just as we see clay-galls now formed on a beach with a cliff of clay. These were deposited in the accumulating sands, which have a greater development on the north side of the hill than on the south. A remarkable confirmation of this view of the case was obtained before leaving the pit. In the south-west corner a series of pale grey sands, containing a band of pale blue clay with lignite in small fragments, seemed to be faulted against a pale blueish clay. On cleaning out the apparent fault, this was observed not to extend into the upper beds, showing that it was not due to vertical displacements, but was in fact the side of an erosion subsequently filled up with another material. Such appearances are termed "horse faults" in the coal mining districts.

The examination of the Woolwich and Reading Beds being thus concluded, the party adjourned for refreshment to the George Hotel, and afterwards inspected a number of bones of Mammalia recently dug out of the Plummery ditch, and which, at the instance of Mr. Harrison Jones, had been kindly lent by the Messrs. Palmer, and were exhibited at the hotel. Some of these occurred in a peaty deposit, along with freshwater shells, below the river sands, and above a bed of gravel. Some came from the lowest gravel. Among the specimens were a portion of a human skull, one half of a horse's jaw, very perfect, with all the teeth; antlers of red deer, very fine; the skull and horn-cores of *Bos longifrons*, and the thigh bones of *Bos primigenius?* besides the remains of smaller animals.

The services of the Director, and of the local gentlemen accompanying the Excursion, having been duly acknowledged, the party in the afternoon adjourned to Caversham Chalk Pit. Here, after speculating upon the origin of certain masses of rotten and re-arranged chalk, which occur on the surface towards the lower side of the pit, most of the Members amused themselves by cracking flints. Although no *Ventriculites* were found, some very pretty sponges were obtained, besides numbers which were reduced to a pulverulent condition, either by the tap of the hammer, or from previous decay on incomplete silicification. Professor Rupert Jones urged the Members to secure and examine some of the white siliceous dust from the round flints, as it consists of beautiful minute organisms.

A walk up Caversham Hill, where the new buildings are being erected, and whence the contour of the country can be well studied, completed a very satisfactory day's work.

THE FIRST IRISH CAVE EXPLORATION.

By G. S. BOULGER, ESQ., F.G.S.

(*Paper read February 4th,* 1876.)

(*Abstract.*)

The greater part of the surface of Ireland presents to view rocks of Old Red Sandstone, Carboniferous, and Pleistocene age. In his celebrated paper,* the late Professor Jukes points out that going round the west coast we find all " the headlands from Kerry Head to Cape Clear are formed of anticlinal ridges of Old Red Sandstone, while the indentations of Tralee, Dingle, Kenmare, Bantry, Dunmanus, and Roaring Water Bays have all been worn in the more easily destructible Carboniferous rocks which lie in synclinal troughs." The Carboniferous Limestone of Ireland is one of the largest aggregates of limestone in the world, but it has been so denuded that, from Dublin to Galway, we can cross Ireland over this formation, without reaching an elevation much above 300 feet; and from Dingle Bay, up the Flesk, down the Blackwater to Cappoquin and on to Dungarvan, only reaching 550 feet on account of a Drift-accumulation, probably 200 feet thick. South of this second line the Limestone only occurs in outliers in the synclinals of Old Red, one continuous range of which runs from Kerry to Helvick Head, near Dungarvan. These large open east and west valleys nowhere rise to more than 200 feet, their general level being under 100, whilst they are crossed by north and south valleys which form narrow and precipitous ravines. As to the mode of formation of these ravines, of which that of the Blackwater at Dromana is a most picturesque example, I certainly think the views of Professors Jukes and Ramsay† more satisfactory than the pluvial-perforation theory of Mr. Tylor.‡ It is in the synclinal of Carboniferous Limestone, here highly fossiliferous, eastward of the Dromana ravine, that the caves I visited, and the one which I assisted Professor Leith Adams to explore, are situated.

It is to be remembered that, as Bischof has shown,§ water containing only one-tenth as much CO_2 as a saturated solution is capable of most readily converting insoluble $CaCO_3$ into soluble $CaCO_4$ or Ca_2CO_5, so that Mr. Prestwich's theory of the abundance of CO_2 in the air in the Quaternary period to account for the Chalk-pipes, endorsed by Mr. Tylor,* seems as unnecessary as is, I believe, the similar explanation of the Carboniferous flora, ordinary rain-water containing ample carbonic acid for the formation of pipes or caves. With reference to the manner in which their contained remains were entombed, it is important to distinguish those cavities which had a wide vertical opening from ordinary caves. Thus hyæna-dens, such as Kent's Hole and Kirkdale, and wolf-dens and shelter-sheds, such as the cave at Shandon, near Dungarvan, differ materially from filled-up fissures, such as those of Malta and Wokey Hole, which only contain remains of animals which have met with an accidental death. The sealing-up of fissures by accumulating surface and made soil, and the possible Pluvial period, should also be considered in reference to the rate of deposit of stalagmite; and, as is well seen, I think, in the plan of Brixham Cave, the direction of joints seems to have determined the ramification of chambers. Besides the ordinary stalagmite and breccia, there were in the Shandon Cave two deposits of interest—a fine, homogeneous, red clay,† and a lava-like mixture of this, with stalagmite, termed by Dr. Adams "stalagmitic red earth."

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* Quart. Journ. Geol. Soc., Vol. xviii.

† " Physical Geology and Geography of Great Britain."

‡ " Geological Magazine," September, 1875, pp. 457,8.

§ " Chemical Geology," Vol. iii, p. 171.

There are numerous caves in county Waterford—some now occupied by *Canis vulpes*, others promising interesting pre-historic relics; that of Shandon, which Dr. Adams and myself explored in June and July, 1875, being situated but a few feet above the present high-water mark of the estuary of the little river Colligan, about one mile from the town of Dungarvan. It was discovered in 1859 by Mr. Brenan, who collected bones of *Elephas primigenius*, *Equus*, *Ursus*, *Cervus tarandus*, *Lepus variabilis*, and a bird, which are recorded on the Survey map.‡ Professor Harkness and Dr. Adams visited it in 1869, and made some additional discoveries.§ In 1875 the Royal Irish Academy made a grant for its exploration to Dr. Adams, who asked me to join him. We met with considerable difficulties; but prejudice was overcome by the countenance of the Roman Catholic clergy, and the clumsiness of workmen and the stubbornness of the matrix by perseverance. Blasting had to be used, the fallen roof having become a solid breccia; but this resulted in the interesting discovery of a large chamber full of remains. Besides those above-mentioned, remains of *Cervus elephas*, *Canis vulpes*, *Canis lupus*, various birds, and perhaps goat were found, including a cast-antler of rein-deer, many bones gnawn by some rodent, others split by the falling fragments, and some showing slight traces of water-rolling. Possibly a small stream, which is visible near the cave at low tide, may once have flowed through it. At high tide the water soaked through into the bed of clay below the ossiferous breccia and cave-earth in the cave. Some of the remains were found loose, among fragments of limestone, apparently preserved by desiccation; others in the clay, breccia, and stalagmite, as is commonly the case. The absence of any trace of man, lion, hyæna, or *Megaceros* may tend to support Professor Boyd Dawkins' views as to the late glaciation of Ireland; but, as it may be hoped that it will not be the last, it would be rash to base generalizations on this first Irish cave exploration,

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* *Loc. cit.*, p. 464.

† This contains no pebbles, and is, no doubt, the insoluble residue of the limestone, as suggested by Professor Morris in the discussion of this paper like the clay on the Chalk Downs (see Ramsay, *op. cit.* p. 263), and unlike the river-mud in Kent's Hole.

‡ See also "Natural History Review," October, 1859.

§ "Geological Magazine," Vol. vii., No. 6, June, 1870.

ORDINARY MEETING, JUNE 2ND, 1876.

WILLIAM CARRUTHERS, Esq., F.R.S., President, in the Chair.

The following Donations were announced :—

"Transactions of the Manchester Geological Society," Vol. xiv., Part 3; from that Society.

"Abstracts of the Proceedings of the Geological Society of London," Nos. 318 and 319; from that Society.

"Quarterly Journal of the Geological Society," Vol. xxxii., Part 2; from that Society.

"Journal of the Society of Arts," May, 1876; from that Society.

"The Geology of the Weald" (Memoir of the Geological Survey), by W. Topley, F.G.S.; from the Author.

"Remarks on the Foraminifera, with Special Reference to their Variability of Form," by Professor T. Rupert Jones, F.R.S.; from the Author.

"Notes on the Memoir on the Variability of Foraminifera," by Professor T. Rupert Jones, F.R.S.; from the Author.

"Review of Dawson's 'Dawn of Life,'" by Professor T. Rupert Jones, F.R.S.; from the Author.

"Review of the Arctic Manual, 1st and 2nd Notice," by C. Cooper King, F.G.S.; from the Author.

"The Ice Age in Britain," by Ralph Richardson; from the Author.

"The Human Body; its Structure and Functions," by T. D. R. Marshall, Second Edition; from W.H. Leighton, Esq., F.G.S.

"L'Eocène Supérieur des Flandres," by M. Charles Barrois; from the Author.

"La Dénudation des Wealds et le Pas-de-Calais," by M. Charles Barrois; from the Author.

The following were elected Members of the Association :—

Mrs. Best; A. K. Campbell-Johnston, Esq., F.R.G.S.; Henry Huctley, Esq.; John Henry Ley, Esq.; C. E. Owens, Esq.; Frederick Pontifex, Esq.; Alfred Tylor, Esq., F.G.S.; and William Whitwell, Esq.

The following Paper was read :—

Notes on the Geology of Lewisham.

By H. J. Johnston Lavis, Esq., F.G.S.

As the Chalk is one of the most important of our Cretaceous rocks, so is it the last of the Mesozoic series in Britain. I will not attempt a detailed description of it, but will notice a few of the leading facts connected with the upper division, called "Chalk with Flints," or "Upper Chalk."

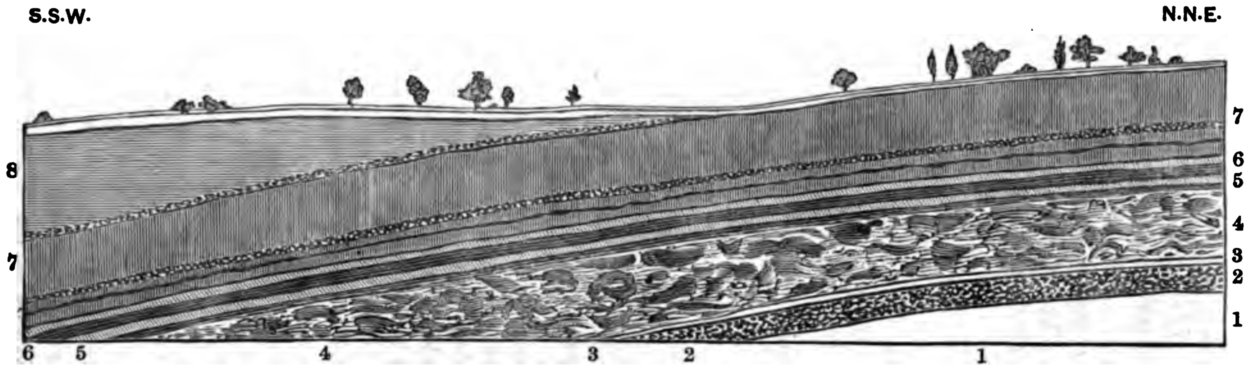
There are two important sections of the Upper Chalk in the neighbourhood of the metropolis to which I wish to draw attention, viz., at Lewisham and Charlton, besides other smaller and less important ones.

The first occurs in the most northern pit of Loam-pit Hill, about a quarter of a mile from St. John's Station. Here we see a face of Chalk of about 45 feet deep, with a base line of about 200 feet, capped by the Lower London Tertiaries. This shows in section two well-marked bands of flints, the first of which is situated about 6 feet from the top, and the second 4 feet below the former. Besides these there are many other less conspicuous bands of the same material. The Chalk here presents in two or three places a kind of cleavage which is parallel to important lines of dislocation or jointing situated close by, of which I shall say more hereafter. The Chalk in this locality is very fossiliferous. Appended is a list of fossils I have obtained from Loam-pit Hill.

Fish remains.
Belemnitella mucronata.
Pecten nitidus?
Spondylus spinosus.
Lima.
Ostrea.
Inoceramus.
Terebratula semiglobosa.
„ carnea.
Rhynchonella octoplicata?
Crania.
Flustra.
Ananchytes ovatus.
Galerites albogalerus.
Cyphosoma.
Cidaris. (?)
Micraster coranguinum.
Goniaster Parkinsoni.
Apiocrinus ellipticus.
Serpulæ.
Escharina, and many other forms of Bryozoa.
Scyphia.
Ventriculites.

The next and largest exposure is situated near Charlton Station, where a very extensive section is seen. The chalk in this pit differs from the Lewisham chalk in being less ironshot. In this is also seen two well marked flint bands, besides subordinate

FIG. 1.—SECTION ACROSS LOAM PIT HILL, LEWISHAM.



1 Thanet Sand.
2 Greenish Loamy Sand with Pebbles.
3 White Sand.
4 Marl and Sand with Pebbles.
5 Cyrena bed.
6 Ostrea bed.
7 Plant bed.
8 London Clay with Basement Bed.

ones; the upper being about 9 feet from the top of the chalk, and the lower 9 feet from the upper. The surface of chalk here exposed is only 25 feet deep, as it cannot be worked below the drainage level; one place where this has been attempted is filled with water. Proportionately this is less fossiliferous than in the former locality, though it is a well-known resort of London collectors. The following are the principal fossils I have obtained from the Charlton pit:—

Saurian (?) bones.
Fish remains.
Lamna.
Ptychodus.
Belemnitella mucronata.
Pecten quinquicostatus.
„ nitidus.
Spondylus spinosus.
Inoceramus.
Lima Hoperi.
Ostrea dilatata.
„ sp.
Thecidium Wetherellii.
Terebratula semiglobosa.
„ carnea.
Crania Ignabergensis.
Rhynchonella octoplicata (?)
Flustra.
Apiocrinus ellipticus.
Cidaris.
Cyphosoma.
Ananchytes ovatus.
Ananchytes pilula.
Galerites albogalerus.
Micraster coranguinum.
Serpulæ.
Vermetus.
Bryozoa.
Ventriculites.
Scyphia.
Choanites.

THANET SANDS.—Resting almost directly upon the Chalk in this locality are the Thanet Sands, the lowermost division of the Lower Eocenes. They derive their name from the fact of their attaining their greatest development in the Isle of Thanet. They consist of a mass of light buff or greenish sands, more or less unfossiliferous in the north-west of Kent, generally ironshot, stratifiation faintly marked, and, when dry, appearing at a distance almost white. The sand is composed of fragments of nearly colourless subangular quartz, intermingled with glauconitic grains, and especially at its lowest part with a white argillaceous substance, which does not stain the sand. This material was probably uniformly distributed throughout the sands during their deposition, but has since been washed down to their lower part by the percolation of water.

Perhaps the most interesting point about these beds is the presence of the constant and well marked band of green-coloured flints which is found in immediate contact with the Chalk. These also occur at the bottom of the Woolwich and Reading Series, where these beds rest upon the Chalk, where they occupy the same position, leading some to believe that they were the representatives of the Thanet Beds in that district. The flints are perfectly unrolled, and therefore could not have been deposited in their present position by marine action; Mr. Dowker considers them to have been left by the sub-aerial denudation of the Chalk; but the explanation of Professor McKenny Hughes and Mr. Whitaker is generally accepted. These gentlemen consider the bed to have been formed by the percolation of water containing carbonic acid through the superposed strata which, on arriving in contact with the chalk, dissolved the upper part away, leaving the flints behind to become simultaneously or subsequently covered by their characteristic green coating. In the neighbourhood of Lewisham there is a fact which would seem to confirm this. Just outside St. John's Station we see the Thanet Sands faulted down against the Chalk. We might expect to find the Thanet Sands in immediate contact with the Chalk, but we find that there is a thin layer of green flints interposed. Now the faulted surface is at about an angle of 40°; the water, therefore, draining through the Thanet Sands and containing carbonic acid, would dissolve away the chalk, though with less power on account of its sloping direction, leaving the flints behind. The bed of flints varies in the neighbourhood from 9 to 18 inches.*

The bed of green-coated flints, the "Bull Head Bed," is overlaid by the Thanet Sands proper. Mr. Whitaker says of this: — "(C) In a railway cutting close to Bekesbourne Station, east of Canterbury, there is a little sand below the sandy marl (D), in which the greater part of the cutting is made, and this I take to be the same as the Thanet Sand of London and the western part of Kent. The only other places in that neighbourhood where I saw anything of it was at Selling. This fine light buff sand thickens westward, and near Sittingbourne forms a considerable part of the Thanet Beds. Further west it gets still thicker at the expense of the beds above, until, on the other side of the Medway, it replaces them altogether, and takes up the whole of the space between the Woolwich Beds and the Base-beds some 60 or 70 feet. It thins slightly in the neighbourhood of Woolwich, and then rather more rapidly, until it dies out west of London."* In accordance with this the Thanet Sands are thicker at Charlton than at Lewisham.

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* I have obtained one flint from this place which was white where imbedded in the Chalk, but the part surrounded by the Thanet Sands was quite green graduating into the white.

He then goes on to say—"No fossils, except some casts of Pholodomya recorded by Professor Prestwich at Erith, have been found in this bed."

To these we can add some casts of the same shell at Charlton, recorded by Professor Morris, and confirmed by Mr. Taylor, besides which, before you is a cast of a *Cyprina*, obtained by Professor Morris and myself from the same locality, and I have lately found two similar casts close together at Lewisham, which I unfortunately broke while extracting them. There was also found by one of Professor Morris' students the cast of a fish vertebra, at Charlton. Small portions of lignite also occur occasionally. In the Woolwich pit, which faces the Thames, the upper part of the Thanet Sands may be seen to have been burrowed by annelids, which were subsequently filled up by the clayey sand of the bottom of the Woolwich and Reading Series, which overlies it. The Thanet Sands proper are considered to be the equivalents of the Landenian series in Belgium of M. Dumont. The Green Flint bed probably is represented by the Argile à Silex, of Professor Hèbert, in France.

THE WOOLWICH AND READING SERIES is the middle member of the Lower Eocene. These beds consist of alternating gravels, sands, and clays, very fossiliferous in parts, almost barren in others. They are of marine, estuarine, and of fluviatile origin.

The bed marked (A and A′ in Fig. 2) consists of a green sand with a number of well-rounded black pebbles. At Lewisham this bed is 6 feet thick, containing very few pebbles, these being more or less equally disseminated through it. At Charlton it is only 1½ feet thick, the pebbles predominating, each individual one being in contact with its fellow, the sand only filling the spaces between them. These pebbles are considered by Mr. Prestwich to have been formed on an island or shoal in the Thanet Sand sea, and were strewn over its bottom at the end of that and the commencement of the Woolwich and Reading period, by the movements of elevation which took place then. The sand was probably

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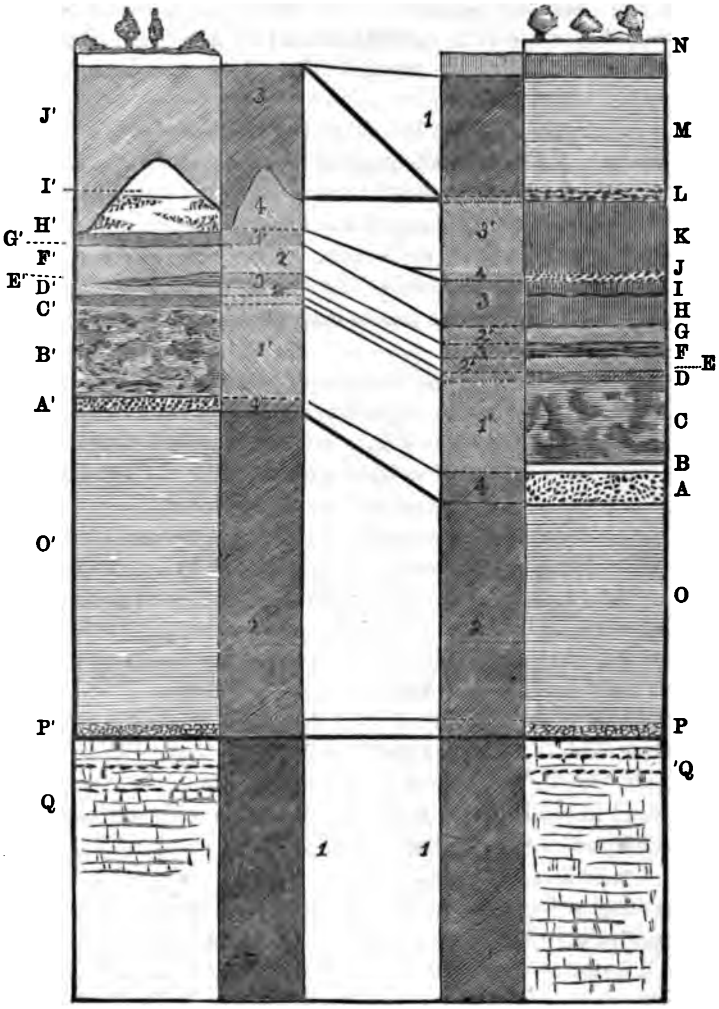
* Quart. Journ. Geol. Soc., Vol. xxii., p. 408.

FIG. 2.—COMPARATIVE SECTIONS OF CHARLTON AND LEWISHAM.



a portion of the Thanet Sand which was washed up and intermingled with the pebbles by the rapid currents then naturally existing. As evidence of this the lowest bed of the series rests very irregularly on the Thanet Sands, as shown in Fig. 3, the bed above it being estuarine in character, showing a change from marine to estuarine conditions. Though generally unfossiliferous, sharks' teeth are sometimes found in this bed.

At Lewisham the Bottom Bed is overlaid by a thin unfossiliferous bed of white or iron-stained sand (B), about a foot thick, which probably belongs to the bed (E). It is unrepresented at Charlton.

The next in the series at Lewisham is a stratum of well-rounded pebbles, imbedded in a small quantity of sand; at Loam-pit Hill it attains the thickness of about 13 feet. The pebbles very much resemble those of the Oldhavens, and when not examined *in situ* could not be distinguished from them. They exhibit much false bedding, and are unfossiliferous. At the upper part of this bed there is a stratum of white friable marl (D), varying from one to two feet in thickness.

At Charlton the bed (C) is represented by the bed (B') consisting of ferruginous sands, sometimes very argillaceous, containing a large number of branching concentric ironstone concretions, often containing fossils of estuarine character. The bed (C') at Charlton occupies the same position as the Marl Bed (D) at Lewisham, but is here chiefly composed of large fossiliferous ironstone nodules, which however are sometimes replaced by sandstone and by marlstone concretions. The stratum, C, at Lewisham may be considered to be estuarine in origin, the false bedding well illustrating the effect that would be produced at the mouth of a river by the rapid currents caused by the ebbing and flowing of the tides. The pebbles were probably derived from the Chalk land which the river drained, being partially rounded in their course down and subsequently finished off at its mouth. The Pebble-bed, C, as seen at Lewisham, is I believe of very local occurrence, being generally represented by finer material, as at Charlton. It probably formed a small shingle bank.

Superimposed on this we meet with the great fossiliferous clays of the Woolwich and Reading Series, which are capable of subdivision into three, viz., the Lower *Cyrena* Bed (E and D'), *Ostrea* Bed (F and E'), and the Upper *Cyrena* Bed (G and F'). The fossils from these beds attracted the notice of the earlier paleontologists, and even at the present time are of considerable interest to London Geologists. In both the localities of Charlton and Lewisham the beds are moderately well-developed, though they differ considerably in relative thickness.

At Loam-pit Hill, we see resting directly on the Marl Bed (D) the Lower *Cyrena* Bed (E). The matrix is a bluish clay but it exists in so small a quantity that the bed is practically made up of shells, the *Cyrena cuneiformis*, *C. deperdita*, and, *C. cordata* being the most abundant, with which are mingled in a much smaller proportion the other shells characteristic of this series. This bed occupies the same relative position at Woolwich, but in this locality contains a greater amount of clay in proportion to the shells, and is only 10 inches in thickness (D'). At the most North Eastern exposure where the overlying Oyster-bed dies out, it is in contact and passes into the Upper *Cyrena* Bed.

In both localities this bed is overlaid by the Oyster Bed (F and E'), a stratum almost entirely made up of the shells of *Ostrea bellovacina* and *O. pulchra*. At Lewisham it is 2 feet thick, at Charlton one foot and a half, and at the eastern end of Woolwich Ballast Pit it dies out altogether as already mentioned.

Above this we again see a *Cyrena*-bed (G and F'). This is the Upper one, though in its lithological and paleontological characters cannot easily be distinguished from the Lower. At Lewisham this bed is only from 2 to 3 feet in thickness, but at Woolwich attains the developement of 6 feet.

During the deposition of the *Ostrea*-bed (F and E') there was probably a subsidence which admitted the sea water necessary for the existence of oysters, but when a subsequent elevation took place, the oysters were replaced by cyrenas.

At Lewisham we have overlying the shelly series, the celebrated Plant Bed of the Woolwich and Reading Series (Fig. 2, H, I, J, K). It is well developed in this locality, attaining the total thickness of about 22 feet. It is here divisible into two parts, by a band of small well-rounded black pebbles varying from 1 inch to 2 feet in thickness (J).

The lower sub-division (H, I, J) which lies between the shell-beds and the band of pebbles, consists of greyish black sand alternating with clay of the same colour, and is about 9 feet in thickness. It contains a large quantity of iron pyrites in the form of irregular concretions which contain now and then the casts of shells and plant stems.

A foot or so beneath the Band of Pebbles there exists a Lignite Bed (I) which forms the floor of the clay pits of Loam-pit Hill towards their southern end. The wood composing it is coniferous and is bored by *Teredo*, the burrows of which are filled with iron pyrites which is very abundant directly beneath this bed. The origin of this lower sub-division is somewhat difficult to explain, but it seems to be marine, though deposited near enough to an estuary for the shells of *Cyrena*, &c., to be washed down and get entombed contemporaneously with the waterlogged wood of the Lignite-bed.

The upper subdivision (J, K, L), or the Plant Bed proper is 13 feet thick; it consists of alternations of clay and sand, the former predominating at the bottom, and the latter at the top. Especially in the lower and more clayey part a large number of leaves may be found which seem to belong chiefly to the water flags. It contains no shells or other remains to denote marine conditions, therefore we may perhaps conclude that it was some estuarine mud-bank upon which grew a scanty and marshy vegetation which was periodically buried by fresh deposits of mud and sand brought down and spread over by rain floods and other agencies. The Pebble Band was formed much in the same way as the Bottom Bed (A), that is by the disturbance produced by change of depth from deep to shallower conditions.

This Lewisham-bed is represented at Woolwich by a well-marked bed (G′) overlying the shell-beds. In character it is not unlike that already described, though in colour it is yellowish, due to the iron being in an oxidized state, and also to the fact of the plant remains consisting of *Dicotyledonous* leaves and seed vessels denoting their growth on dry land. The presence of this bed at Woolwich was never before known; it may be well seen in the Woolwich Ballast Pit overlying the Upper *Cyrena* Bed, from which it is characterized by its yellowish brown colour.

At Lewisham, the Woolwich and Reading Series terminates with the Plant Bed, but at Woolwich we have overlying it 15 feet of gravels and sands (H′, I′) which were classed by Mr. Whitaker with the Oldhaven Beds.

(H′). The lower portion of this is composed of sands and pebbles interstratified with each other, and showing much false bedding. They rest conformably upon the underlying Plant Bed. The pebbles are well rounded and the sand is flinty. This bed is very fossiliferous and is characterized more especially by the presence of the well known *Cyrena tellinella;* this is generally found, in its natural position, buried in the sand. The shells are generally intermingled with the pebbles and are in a moderately good state of preservation. This bed is 7 feet thick.

The upper bed (I′) is merely a continuation upwards of the stratum just mentioned, differing from it in being totally unfossiliferous, and containing no pebbles, being chiefly composed of white and yellow sand with a very small quantity of clay; its greatest thickness is from 6 to 7 feet. Like the Thanet Sands its surface, which is in contact with the overlying series, is bored by an Annelid or Mollusc to a depth of a foot, the boring being filled up with material partly argillaceous and therefore appearing more prominent than the surrounding sand.

Both of the last mentioned beds (H′I′) have suffered much denudation. One may observe in the section at Woolwich that the Oldhaven and Blackheath pebbles lie very unconformably to these beds; in some places they are entirely swept away, and the Oldhavens rest upon the Plant Bed, which being composed of clay was less susceptible to disturbing influences than the loose gravels and sands. The resemblance of these two sub-divisions of the Woolwich and Reading Series has led Mr. Whitaker to consider them a part of his Oldhavens, but, perhaps, the section was in a less favourable condition when that gentleman examined it than it is at present.

These beds were probably formed much in the same way as the bed C of Lewisham, but the action was not nearly so powerful, for otherwise the delicate shells that are found mingled with the pebbles would have been reduced to powder. The sea could not be far off, inasmuch as forms like *Lamna*, *Fusus*, *Murex*, *Natica*, *Pectunculus*, &c., could not have existed without much sea water.

We now arrive at beds which present some difficulty—namely, the so-called Oldhaven and Blackheath Series. They are composed of perfectly rounded pebbles, intermingled with sand, which varies in quantity, and show extensive false-bedding, the axes of the pebbles being sometimes as high as 45° to the dip. They play a very important part in the geology and physical geography of this neighbourhood, where they attain the thickness of 40 to 50 feet,* the Blackheath plateau being entirely due to their presence, inasmuch as being very permeable to water, which sinks as soon as it falls, instead of running off the surface and carrying materials away with it, and makes its appearance as small springs, which run out just above the out-crop of the Woolwich and Reading clays.

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* Rev. De la Condamine, Quart. Journ. Geol. Soc., Vol. vi, p. 445.

These Pebble-beds, and the uppermost sands of Upnor and Reculvers, Professor Prestwich classes with his Basement Bed of the London Clay, as representing the pebbly loam which occurs at the bottom of that formation in the West; * but Mr. Whitaker makes a line of demarcation between them at Oldhaven Gap and then proceeds to separate them in every other district.† In the locality under consideration, where the development of this series is very great, and, therefore, weighty in the consideration as to their classification, there are many points of interest to be carefully studied.

They appear to lie conformably to the Plant Bed at Lewisham, but, as already mentioned, not so at Woolwich. Now, as the London Clay generally rests very conformably upon the Oldhavens, we might consider that there was evidence that they belonged to the London Clay. Mr. Whitaker shows in his list of fossils a decidedly estuarine fauna, and then states his belief that they were formed on an old shingle bank which was well out at sea, where no unrolled flints could arrive without being first well rounded. How is this to be reconciled?

He divides them from the London Clay at Herne Bay entirely on palæontological grounds, apparently not taking into consideration that the fauna of a sandy bottom would change as clay took the place of sand, and as probably the water became deeper; in fact, in this locality there is a transition from the Woolwich and Reading Series right up into the London Clay.

The explanation of their origin as given by Professor Prestwich appears to me the more probable one. He seems to consider that the termination of the Woolwich and Reading period and the commencement of the London Clay epoch was marked by the elevation of a ridge of land to the south and a corresponding depression to the north. This would cause very active and powerful currents, and it is very probable that part of the land over which the rivers of the Woolwich and Reading period had flowed, and upon which they had deposited their valley gravels, was submerged, and the already partially-rolled pebbles were com-

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* Quart. Journ. Geol. Soc., Vol. ii., pp. 254, 255, 261, 265; and Vol. x., pp. 105, 107, 110, 111, and 130.

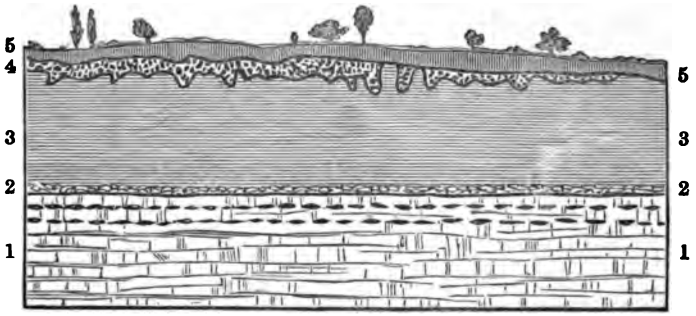
† Quart. Journ. Geol. Soc., Vol. xxii., p. 414.

pletely rounded and deposited in a very irregular manner by this powerful but transient action; so that at one place, such as Blackheath, they are 50 feet thick, and only three-quarters of a mile distant at Loam-pit Hill, they are not five inches. It is also probable that a large quantity of these pebbles and sand is nothing more than the resorted estuarine portions of the underlying series, such as the beds (H′ and I′), which are seen to have suffered much denudation at Woolwich, and yet may have extended over a very considerable area. Another point of interest is recorded by Professor Prestwich in a section at White Cliff Bay, where he found pebbles of red clay derived from the underlying mottled clays; and also at Herne Bay he found green flints, which must have been derived by the denudation of the Thanet Sands. *

We now arrive at the London Clay proper. There are numerous sections of it in this neighbourhood, but by far the most illustrative is at Loam-pit Hill, where it is exposed in section in the brick-pit. It is here about 20 feet thick. It presents the ordinary character of London Clay, but contains no septaria. It is also totally unfossiliferous, which Professor Prestwich explains by the fact that it required some considerable time for the emigration of a fauna suitable to a muddy sea.

Between this and the overlying Pleistocene deposits in this area there are no representatives of the deposits of the enormous period, during which the deposition of the Middle and Upper Eocene, the

FIG. 3.—SECTION IN CHALK PIT NEAR ST. JOHNS.



1 Chalk with Flints.
3 Thanet Sands.
2 Green-coated Flints.
4 Woolwich and Reading Beds.
5 High Level Gravel.

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* Quart. Journ. Geol. Soc. Vol. vi., p. 277.

Miocene, and the Pliocene formations took place on other areas. The Pleistocene is represented at Lewisham by the mammaliferous brick-earths and gravels of the Thames, and especially of its tributary, the Ravensbourne, two sections of which are well worth notice—the first situated close to some new houses facing Loam-pit Hill, and the other, from which numerous bones and teeth have been obtained, is seen, in a brick-yard opposite the Angel Inn on the road from St. John's to Lewisham. There are also deposits of High-level Gravels covering the greater part of Loam-pit Hill, resting very unconformably on the Woolwich and Reading Beds, as shown in Fig. 3, and also on the London Clay in Mr. Hodson's brick-pit near Turwit Road.

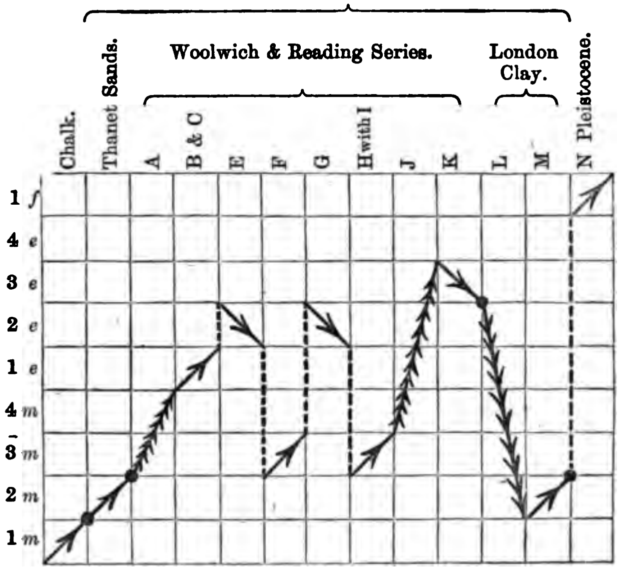
The Upper Chalk forms the foundation upon which the different Lower Tertiary deposits took place. Professor Prestwich considers that the elevation of the Weald took place to a certain extent during the latter part of the Cretaceous period; that there was but a very thin deposit of Chalk over an area which he describes as follows:— "It is probable that there was some extent of dry land, possibly an island, somewhere intermediate between a line drawn on the north from Farnham towards Canterbury, and on the south between Winchester and Newhaven, and extending eastward into the north of France, and that the long-continued wear on its coast accumulated on the shores extensive banks of pebbles, whilst the finer sediment produced at the same time, in conjunction with the débris brought down by the operation of streams, formed at a distance from the land the strata of this oldest Eocene epoch." He considers the Thanet Sands to have been derived by the denudation of the Greensand; he does not account, however, for the absence of flint sand mixed with the Thanet Sands, which must have been formed by the rolling of the flints which had been derived from the thin layer of chalk; the pebbles he says were afterwards spread over the sea bottom by other agencies during the Lower and Middle Eocene period.

It is a curious and interesting fact, and is well illustrated in this locality, that the Thanet Beds seem to rest on an almost perfectly smooth and even surface of chalk, the lines of stratification being quite parellel, so that one might be led to imagine that there was a direct sequence instead of a great break in time, both paleontologically and stratigraphically, during which the Calcaire Pisolitique, Mæstricht Beds and the Faxoe Limestone were being accumulated.

FIG. 4—ILLUSTRATING THE CORRESPONDING CONDITIONS OF DEPOSITION AT LEWISHAM AND CHARLTON.

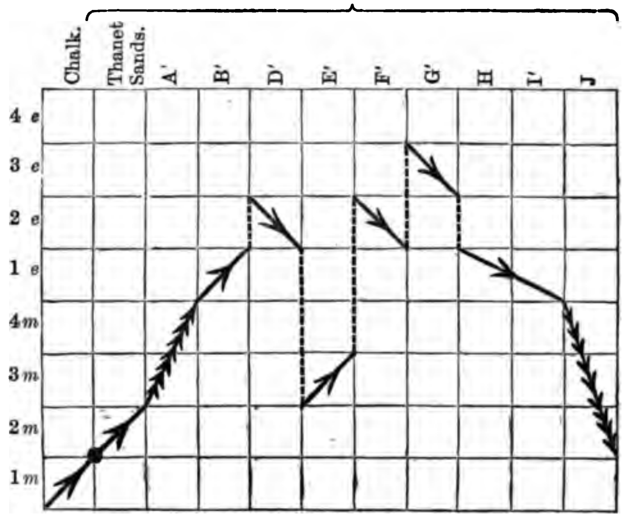
LEWISHAM.

EOCENE.



CHARLTON.

EOCENE.



m Marine.
e Estuarine.
Fluviatile.

Λ Water Deepening.
V „ becoming Shallower.
>>> Passage Bed.
● Break in Time.

¦ Rapid movement from one condition to another.

As we in fact know that there is an "apparent" transition between Secondaries and Tertiaries in Denmark, represented in England by a great break in time; so it is found that in one locality there is a passage between one member of the Lower Tertiaries and in another place there is a decided break and sometimes an unconformity. This is the case with the Thanet Sand in the east of Kent, where they pass insensibly up into the Woolwich and Reading Series, it being almost an impossibility to draw a line of division between them, whereas westward, as at Loam-pit Hill, there is a decided boundary line besides a slight unconformity as shown in Fig. 3.

MINERAL CONTENTS.

Calcite is found crystallized inside empty echinoderm shells, and sometimes in terebratulæ from the Chalk. It also occasionally occurs crystallized in the oyster-shells from the *Ostrea* Bed of the Woolwich and Reading Series, and in the septaria of the London Clay near London.

Iron Pyrites.—This is sometimes, though rarely, found in the Chalk of this locality. It is most plentiful in the Plant Bed at Loam-pit Hill. It is also found lining some of the shells of the *Cyrena*-beds in both localities as well as in the London Clay.

Selenite.—Very fine crystals of this form of sulphate of lime, sometimes quite perfect, at others forming beautiful stars, are to be found most plentifully in the London Clay at Loam-pit Hill; in less numbers and much smaller in the upper part of the Plant Bed. It is also in the Upper Plant Bed that Professor Martin Duncan, Pres. G.S., described spaces in the clay from which the selenite which formed them had been removed.

Hæmatite occurs, though rarely, and in no case have I seen it more than half an inch thick, in the Ironstone Bed of the Woolwich and Reading Series at Woolwich.

Lignite occurs in the largest proportion in the Woolwich and Reading Beds, but it is sometimes found in the Thanet Sands and London Clay.

Quartz in a pure state, crystallized in its characteristic six-sided prisms, surmounted by a pyramid of as many sides, occurs in the Chalk flints, generally having some relation to a sponge cavity. It is most plentiful at Lewisham.

Silica (*Amorphous*) occurs as flint containing a small proportion of iron, carbon and manganese.

Silicate of Iron is the material which gives the characteristic and well-marked green coat to the flints at the base of the Thanet Sands. This was formed after the chalk covering had been dissolved away from them by the sesquioxide of iron contained in the flint, changing elements with the clay of the bottom of the Thanet Sand thus:—

Sesquioxide of Iron. Fe_2O_3 $Al_2O_3,2SiO_2,2H_2O$ Silicate of Alumina of the Clay.	X	$Fe_2O_3,SiO_2,$ A_2O_3,SiO_2,H_2O	The green coating of flints. to form with water a Hydrous Silicate of Alumina or Allophane.

The green colour is very permanent, so that flints coloured with it can be detected in any gravels of later date.

Allophane is a hydrous silicate of alumina containing 40 per cent. of water. It was first discovered at Charlton by Professor Morris, who read a paper upon it before the Geological Society. It was, he says, "formed after the deposition of the Thanet Sand and the slight dislocations these have undergone since. It is found lining the fissures in the Chalk for some considerable depth." It is amorphous, and may generally be recognised by its resemblance to common gum. When broken it breaks with a resinous fracture. In one place where I saw it, in a small pot hole, it was more than six inches thick, though it seldom is a twelfth of that thickness.

I cannot conclude without expressing my deepest thanks to Professor J. Morris, F.G.S., for many valuable hints and much kind assistance.

EXCURSION TO SWINDON AND FARINGDON.

JUNE 5TH (WHIT-MONDAY), AND FOLLOWING DAY.

Directors—Professor JOHN MORRIS, F.G.S., CHARLES MOORE, Esq., F.G.S., and E. C. DAVEY, Esq., F.G.S.

(*Report by* W. H. HUDLESTON, ESQ., M.A., F.G.S.)

On the arrival at Swindon of the party from London, Mr. Moore, who had just come up from Bath, at once led the way to the brick-pits near the Station, which have yielded the magnificent remains of *Omosaurus armatus*, *Bothriospondylus suffossus*, and *Pliosaurus brachydeirus*, figured by Professor Owen in the last volume issued by the Palæontographical Society. At the period of the visit about 20ft. of beds were exposed, being a portion of the Upper Kimmeridge Clay. Such discoveries as those alluded to are, as may be imagined, not often made, and the pits did not yield any considerable number of fossils to the party; a small form of *Astarte ovata* is one of the most common shells, together with an *Ostrea* (*O. expansa?* Sow.), in several stages of growth. There are plenty of impressions of *biplex* ammonites, but belemnites are said to be rare in the Upper Kimmeridge. The character of this formation is further disclosed by a fresh cutting on the north side of the steep hill on which Old Swindon stands, though the junction with the "Portland Sands" is a little obscured by the sliding forwards of the upper beds. The Kimmeridge Clay seen here is perhaps 60 or 70ft. above any worked in the brickyards, and contains hard, concretionary bands, dipping southwards into the hill at a considerable angle. *Ammonites biplex*, *Cardium Morinicum*, *Thracia depressa*, &c., were noted; but the *Cardium* and *Trigonia* bed, at the base of the Portland Sands, was not visible on the occasion of this visit.

The town of Old Swindon is built on the flat top of a detached eminence, which forms part of an imperfect chain of heights marking the outcrop of such remnants of the uppermost Jurassic rocks as have escaped denudation in this part of England previous to the deposition of the Lower Cretaceous (Neocomian) series. These uppermost Jurassic rocks, usually known as Portlandian and Purbeck Beds, have been wrought for a long period of time in vast quarries on the south west side of the town. To these quarries the party, now largely reinforced by a fresh accession of Members and their friends, including amongst others Dr. Wright of Cheltenham, were conducted immediately after lunch. The following announcement of what was to be seen here is extracted from the Circular. "PURBECK BEDS.—Freshwater Marls and Limestones, 10ft. thick, with depressions containing material from the Lower Greensand. Mr. Moore will exhibit from these beds an interesting series of remains, including *Plagiaulax*, *Spalacotherium*, and other mammals. *Macellodus Brodei*, *Nuthetes*, *Goniopholis crassidens*, the tooth of a megalosauroid reptile, apparently allied to the *Cetiosauri*, and other reptilian remains—*Batrachia*, including the oldest known true frog—together with fruits and seeds, and some of the Mollusca of the period."

Having selected a convenient position, Mr. Moore pointed out to the Members the principal features of the general section, and gave a brief description of the results he had obtained by a careful observation of the beds during a period of 15 years. "Four distinct formations might here be noted. 1. The pipe-like veins atop filled in with remanié Lower Greensand. 2. The Purbeck Beds. 3. The Portland Rock. 4. The Portland Sands. In the quarry generally the stone is of an intermittent character, there being, towards the base, layers of loosish material, with bands of nodules and continuous rock-bed—Portlandian. These are succeeded by a series of chalky-looking limestones, in which may be observed one or two darkish bands, something akin to the dirt-beds of the coast districts. These black bands are earthy carbonaceous marls and loose grits, and are found to contain a remarkable mixture of marine and freshwater forms. The whole of this series is referred to the Purbecks, but the chalky limestones or marls contain few remains of a recognizable character. Hitherto no Mammalia had been quoted from the Purbeck of Swindon, but a reference to the Circular would show that this void had been filled up. He might mention also *Paralestes* in addition; and to the list of Reptilia he would add *Saurillus*. Of fishes there was *Lepidotus*, and peculiar forms with very small teeth, but it must be admitted that the remains were often fragmentary and difficult of identification, everything vertebrate having been much washed about. As regards Batrachia none were known between the Purbecks and the Tertiaries; yet he could not doubt that the specimens secured from these beds were authentic, and that they really belonged to the period in question, their mineral condition being precisely that of the other fossils, about which there could be no question. Respecting plants, there was much trace of vegetable matter in these black bands. He had made out the seeds and stems of at least two species of *Chara;* nor could he be mistaken in assigning to the dock tribe certain specimens showing the capsule, with the seed peeping out from it, the mineral condition of which could leave no reasonable doubt as to these specimens of a dicotyledonous plant—unique as far as our present knowledge goes at that early age—being really contemporary with the other fossils. Of Mollusca, *Planorbis, Hydrobia, Valvata, Physa, Nerita, Trochus, Limnæa, Dentalium, Cerithium, Ostrea, Cytheræa, Arca*, were amongst the singular mixture of marine and freshwater forms which these black bands contain. Of Crustacea he had obtained four or five species of *Cypris;*

two forms, possibly two distinct genera of Bryozoa; *Pentacrinites;* rarely the spines of an echinite ; *Nodosaria* and *Flabularia* amongst Foraminifera; and finally coprolites and derived pebbles. The question naturally arises: to what stage of the Purbecks, as exhibited in the Swanage district, should these beds be referred? There are at Durdlestone between 200 and 300 ft. of beds. On the whole he was inclined to refer these to the Middle Purbecks, though the series, as here developed, may have been the result of currents cutting out and modifying beds previously deposited."

Mr. Moore concluded by stating that, whereas the Geological Survey in their published Memoir, enunciated no more than seventeen species from the Purbecks of Swindon, he had been able to add eighty species to the list. Some of these treasures he proceeded to exhibit as vouchers for what he had already stated. These were critically examined by several of the party. The bones of the "oldest known true frog," were especially scrutinized, but no material difference in its mineral condition, whereby it could be distinguished from other associated remains, was detected. A small phial full of the teeth of *Macellodus* was exhibited, some of the specimens being much larger than any hitherto figured. Specimens of most of the genera above enumerated, were also exhibited, forming altogether a remarkable collection of micromorphs, and reflecting the highest credit on the skill and industry of Mr. Moore.

Professor Morris, another of the Directors, then briefly alluded to the physical history of the formations of this immediate district.

"The Portland Beds, being the latest of all the Oolites, are seen to rest on the Kimmeridge Clay, and in some cases, as at Aylesbury, there is a band of dark pebbles marking the base of the series. These Portlandian Beds form the third and least important, because most irregularly developed, of the four great lines of escarpment which occur in this part of England, viz., (1) the Cotteswold or Lower Oolite escarpment; (2) the Corallian, most marked in the ridges of Wootton Basset, and Highworth; (3) the Portlandian, on which we now stand; and (4) the Chalk escarpment which might be seen closing in the landscape on the south. Referring to the development of the formation, the hard tabular limestones of the Isle of Portland are again met with at Upway (near Dorchester), and also in the Vale of Wardour, at which place they are associated with a considerable development of the Purbeck Beds. As we proceed north, however, the character of the Portlandian series is more sandy and uncertain, and the Purbecks, too, show a corresponding diminution as at Shotover near Oxford, where the Portland limestones (as such) are altogether absent, and the Purbeck have gone out with them, although on the southern part of the hill they are both seen at Combe Wood and Garsington. The Portland Beds may be further traced at Thame, Brill, and with the overlying Purbecks at Hartwell and Whitchurch, near Aylesbury, beyond which there is no further exhibition of "Portlandian" Beds in England, excepting a small and doubtful development at Speeton, in Yorkshire. It was evident that, during the deposition of this series, there was a gradual uprising of the Oolitic area, producing a tendency to brackish water, and finally even, in some places, to freshwater conditions. He had great pleasure in bearing witness to the interesting and suggestive nature of Mr. Moore's discoveries in connection with these partially freshwater beds, and in answer to his question as to what portion of the Swanage Purbecks they represented, he ventured to suggest that they might be the equivalents of the entire thickness (300ft.) there displayed. With regard to some of the genera occurring in these kind of beds, he alluded to the presence of *Corbula*, in true Purbeck strata of marine character, at Wimereux in the Boulonnais, and in the Lower Wealden at Pounceford in Sussex, as well as at Swindon. There are species of *Arca* too, which are capable of living under freshwater conditions.

"The last formation in the quarry which required notice was the Lower Greensand, here only existing in an imperfect and remanié condition. But in this district the various Oolites are transgressively covered by some member of the Neocomian series. At Seend, for instance, we have the marine shells of this period in a ferruginous grit, resting upon Kimmeridge Clay, whilst in the opposite direction the party would observe to-morrow at Faringdon, the Kimmeridge Clay and Coral Rag, covered by the remarkable Sponge Gravel, now well known to belong to the Lower Greensand. At Shotover and at Hartwell the Portland Series is capped by beds containing *Unio*, *Cyclas*, and *Paludina* pointing to freshwater conditions, but still of Neocomian age. All this would seem to indicate that the old land surfaces, disclosed in the interval (represented by the Wealden and its equivalents, the Lower and Middle Neocomian) which bridges over the Oolitic and Neocomian periods were still in existence when a portion of these latter began to be formed. Ultimately a depression, marking a stage of the Neocomian period, set in, and a great and unequal erosion of beds of various ages was accomplished. In the hollows and gullies thus formed the pebbly Lower Greensand (Upper Neocomian) of this region was deposited, and in this way it came to be transgressive over so many formations."

Having heard thus much from the two Directors, the members of the party set to work to examine the various portions of the quarry for themselves. The Portland Beds, as pointed out by Mr. Moore, were observed to consist of impure gritty limestones, intercalated between looser sands, the latter predominating towards the floor of the quarry. Calcareous casts of *Ammonites giganteus*, *Trigonia gibbosa*, *Cardium dissimile*, *Cytherea rugosa*, &c., are plentiful enough, just as in the Isle of Portland itself. Towards the east end of the quarry the so-called Purbeck Beds overlie the Portland Beds in considerable force, and the black carbonaceous friable loam, in which Mr. Moore has found so many fossils, is well developed at this point. Almost the first fragment which that gentleman split with his hammer was found to contain a fine tooth of *Goniopholis*, the Swanage Crocodile. Further on the same bed was observed to be a mass of *Cerithium Portlandicum*, the shell itself (not the cast) being preserved in a dark friable marly grit. But the most noteworthy circumstance here is that, above this bed, the regular Portland limestone comes on again rich in casts of the usual Portlandian shells, showing most clearly how "Purbeck" and "Portland" conditions inosculated at this spot, and that if *names* are to be rigidly adhered to, without reasonable modification of their meaning, according to local circumstances, we actually have the Portlandian overlying the Purbeck on the east side of the great quarry at Swindon.

TUESDAY, June 6th, found nearly the same party assembled at Faringdon about 10 a.m. Mr. Moore and Dr. Wright were absent, but Mr. C. J. A. Meyer, had joined. Mr. Davey assumed the lead, and was ably assisted by Professor Morris and Mr. Meyer. The great features of interest in this district are the Sponge Gravels of Lower Greensand age, but there are also some instructive sections of Corallian beds. The party drove to Badbury Hill, a commanding point, situated in the escarpment which overlooks the valley of the Upper Thames, about two and a half miles to the west of Faringdon. The subjoined extract from Mr. Meyer's

Paper (*) will serve to show the nature of the equivalents of the Red and Sponge Gravels of the pits subsequently visited.

" Our next excursion was to Badbury Hill. In a small pit near the roadside, on the west slope of the hill, and at about 50 feet from the top, we found a section exposed, which was to me by far the most interesting one I had yet seen. The section was as follows:—

†	Light-coloured and ferruginous sand, with slabs and fragments of chert, apparently the debris of higher beds ...	14 feet.
a	Fine ash-coloured sand, *regularly stratified*, very like the sands with clay beneath the ironstone of Furze Hill ...	4 feet.
b	Dark brown and ferruginous sand, with a mixture of small pebbles, Bryozoa, Terebratulæ, &c., regularly stratified...	4 feet.
c	Ditto, ditto, with two or more bands of hard calcareous concretions, each about eight inches in thickness	5 feet.

This last was the lowest stratum exposed, but from the appearance of the soil the pebbly sands extended somewhat lower.

In the looser materials composing the strata *b*, *c*, we immediately recognised the upper portion of the Red Gravel of East Pit, containing here, as there, *Rhynchonella nuciformis* in abundance, *R. latissima*, *R. depressa*, *Terebratella Menardi*,† *Terebratula Tornacensis*, *T. depressa*, more rarely; and, in addition, a few specimens of *Terebratella oblonga*, Sow.

In the intermediate stone beds, *c*, *T. oblonga* was not uncommon, associated more rarely with *R. depressa*, *T. Menardi*, *T. depressa*, and *T. Robertoni*, D'Arch. The stone also contained *Avicula Rauliniana*, D'Orb., *Pecten Raulinianus*, D'Orb., *P. orbicularis*, *Exogyra conica*, var., and *E. haliotoidea*—shells which occur in the 'Bargate stone' and 'Pebble beds' of Godalming. In fact, except from the greater abundance of organic remains, this section agrees precisely with a section exposed in a quarry of the Lower Greensand near St. Katherine's Chapel, Guildford, where 'pebble beds' alternate, for a thickness of 20 feet or more, with layers of the 'Bargate stone.'

I was greatly pleased at finding *Terebratella oblonga* here in such comparative abundance, associated with *T. Menardi*, etc., as I had only met with a single specimen in the Sponge Gravels. Yet what seemed to me of greater interest in this Badbury Hill section was the upward passage of the dark-coloured pebbly gravel *b* (Red gravel) into *a*, thus, as it were, limiting the position of the Sponge Gravels with a definite vertical range; the fine sandy strata, *a*, underlying the ferruginous sands with chert and ironstone as well here as at Furze Hill and Faringdon Clump.

From what I have now seen of the several sections in the neighbourhood, I can form but one opinion of the Sponge Gravels with relation to the surrounding deposits, viz., that the true 'Sponge Gravel' of the Windmill Pit is unquestionably *the oldest of the Cretaceous deposits near Faringdon*, the strata exposed in the sections of East Pit and Badbury Hill forming as

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[*] Geologist, Vol. vii., page 5, *et seq.*

[†] Now recognised as the *T. truncata* of Sowerby.

nearly as possible a continuous series; while at the same time there is no reason to doubt that the fossiliferous concretions capping Furze Hill are identical with the ironstone concretions which occur near the top of Badbury Hill, intermingled here and there with the cherty fragments."

In the above Paper the author gives comparative sections at 1, Furze Hill, 2, Badbury Hill, 3, East Pit, Little Coxwell, 4, Windmill Pit, Little Coxwell—the two latter were visited later in the day.

On returning to the summit of Badbury Hill, the party listened to a physiographic description of the surrounding country from Professor Morris, who pointed out "how much the scenery, the agriculture, and the life of a district is due to its geology. Here the view towards the north west is bounded by the south-easterly slope of the Cotswolds, the surface inclination being rather less than the angle of the dip. In the immediate foreground towards the north was the vale of the Upper Thames, which lay in the plain of Oxford Clay, between the Lower Oolites of the Cotswolds, and the Corallian escarpment, of which Highworth might be deemed the culmination, but which, at Badbury, was heightened by the superposition of the Neocomian beds they had just seen. Neglecting the small Portlandian escarpment, almost unnoticeable from this point, they saw on the south the Vale of White Horse, excavated out of the Kimmeridge and Gault Clays, and extending along the foot of the third (at Swindon enumerated as the fourth) great escarpment, formed by the Chalk hills above Wantage. Thus three clay vales, viz., that of the Lias, the Oxford Clay, and the Kimmeridge-Gault, were subtended by three limestone escarpments. The quantity of Boulder Clay on this side the Thames about here was insignificant."

But the masses of silicious grit or Grey Wethers, remnants of strata of Tertiary age, found in the low grounds beyond the Chalk escarpment near Swindon, attest the waste to which the whole district has been subjected, and clearly show, as explained by Professor Ramsay, how the Chalk and overlying Eocene beds once spread far across the plains which the Chalk escarpments overlook, and which latter have thus gradually receded eastward.

Mr. Davey then read out to the party some notes on the subject of Badbury Hill, of which the following is an extract:—

"The Camp is two hundred yards in diameter, with a ditch twenty feet wide. Some nine years ago (written about 1800), in levelling the north rampart, human bones and coals were found and human bones are found every year in digging for peat in the swampy ground about one mile south of the hill. Leland, in his 'Itinerary,' says that he learned of certainty, that 'a mile out of Faringdon towards the right way to Highworth appeared a great ditche, wher a fortresse, or rather a camp of warre, had been, as some say, diked by the Danes as a sure camp.' Mr. Wise, in his letter to Dr. Mead, supposes that the battle of Mont Badonicus, or Badbury Hill, in the year 520, mentioned by Gildas and Bede, was fought hereabouts.

"Mr. Austen found fossil wood and the leaflet of a fern on the tabular summit (Quart. Journ. Geol. Soc., Vol. x., 457); Mr. Cunnington, *Terebratella oblonga* (Quart. Journ. Geol. Soc., Vol. x., 177); myself, *Domopora, Emarginula Neocomiensis, Turbo, Rhynchonella Gibbsiana*," &c.—

The party then descended by a pleasant route across the fields to Great Coxwell Barn, which is favourably situated on Corallian limestone by the side of a spring, thrown out at the base of the Neocomian sands, which are an extension of those on Badbury Hill. This is effected by a narrow belt of Kimmeridge Clay interposed between the sands and the limestones. The contrast between the vegetation of the poor, hungry sands, covered with short grass and daisies, and the golden meadow formed by the mixture of the sands and clay below, could not have been more sharply indicated by colour on a map. The old monastic barn, built in the year 1204, is still made use of by Mr. William Gerring, the tenant of this portion of Lord Radnor's estate. Its lofty proportions and pleasant shade were not the less welcome to the Members, after their warm walk, because of the beer and bread and cheese which the forethought of Mr. Davey had provided for their refreshment.

The next move was to the celebrated Sponge Gravel pit, the "Windmill Pit" of Meyer's Section, previously quoted, but usually known as Ballard's Pit, situated near the village of Little Coxwell. This place has long been celebrated for the crowds of fossils which it contains, and it has in consequence attracted the attention of geologists. Mr. D. Sharpe* has given a description of the Sponges, and other remains, which he was induced to refer to the period of the Chloritic Marl, an opinion we have seen combated by Mr. Meyer, whose views are generally acknowledged to be correct. Further details, with admirable photographs of some of the sponges, are to be found in an article in the "Proceedings of the Newbury Field Club," written by Mr. Davey, who, in a subsequent memoir on the Faringdon Sponges, has, with the approbation of M. E. de Fromentel, materially altered the names given by Sharpe. Thus *Manon peziza*, one of the commoner forms, becomes *Chenendoscyphia peziza; Manon pulvinarium*, a small rounded sponge, with detached circular slightly marginated oscula, becomes *Oculospongia Faringdonensis*, Davey; *Manon porcatum*, another common form, becomes *Chenendoscyphia sulcata*. Besides these, some of the commoner forms, adopting Sharpe's names only, are *Tragos Faringdonense*, *Scyphia furcata*, *Manon macropora*, and *Verticillites anastomosans;* the latter a form peculiar to Coxwell, "consisting of numerous close-set fistular spongites, not hollow throughout, but divided into a series of chambers by horizontal, perforated diaphragms." Besides the sponges there is an abundance of Polyzoa, Echinodermata, and Brachiopoda. *Peltastes Wrightii* (tests), and the spines of *Cidaris Faringdonensis*, are specially numerous. Fragments of the spines of *Cidaris florigemma*, derived from the Coral Rag, also occur. Thanks to the assistance of Mr. Davey and the quarrymen, a great quantity of fossils were secured. (For further particulars, consult the Papers of Sharpe, Meyer, and Davey, previously quoted.)

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* Quart. Journ. Geol. Soc., Vol. x., p. 176.

Despite its gravelly appearance, the calcareous nature of the general mass is evident, most of the sponge fragments themselves being calcareous. The formation generally is loose and porous, with deep potholes towards the top filled in with an admixture of the Red-gravel, so well exhibited in the next pit (Boutcher's). There are a few bands of hard stone of a greenish or pinkish tinge, due probably to the suffusion and partial decomposition of glauconitic matter.

Mr. Meyer "considered that the Sponge Gravel here reposed partly on Kimmeridge Clay and partly on Coralline Oolite. Referring to the previous history of the area, the Kimmeridgian shore lay within that of the Coralline, which itself was more confined than the Oxfordian; the period of greatest depression, and consequently, the most extended sea, having occurred towards the middle of the Oxfordian epoch. In the latest Jurassic times there was still less water space, and even this had been encroached upon towards the close of the Wealden deposits. Ultimately, however, the Neocomian sea invaded the Wealden area: the first deposit was the Atherfield Clay, succeeded by the Kentish Rag and Sandgate Beds. Then there was a great extension of the sea over these parts, when the Folkestone-beds, with their equivalents, the Pebble-beds and Bargate Stone, were deposited. To this period belong beds at Guildford, Shanklin, Upware, Potton, and Faringdon, rich in Brachiopoda, and often in Sponges, whose geological position is towards the top of the Sandgate and the base of the Folkestone-beds. There was a considerable difference, as he had already indicated on Badbury Hill, between the deposits of this (Ballard's) and the adjoining (Boutcher's) pit. In the latter the sands were much redder, and more gravelly, and the fossils, on the whole, different. The gravel of Boutcher's Pit underlies the ironsand of Furze Hill, but it seems probable that the Sponge Gravel of this pit (Ballard's) does not pass *continuously* under any of these other beds. It was true that there was a certain resemblance between the Brachiopoda of the Tourtia beds of Belgium (representing our Chloritic Marl) and these, but (as was subsequently corroborated by Professor Morris) the resemblance was one of representation rather than of identity. Thus we have here *Rhynchonella latissima*, in the Tourtia *R. compressa;* here *Terebratella truncata*, in the Tourtia *T. Menardi*, and so on. As regards the mode of occurrence of this great Sponge bed, in the Neocomian sea the Coral Rag would here rise in ridges on which the sponges grew in suitable localities. Towards the south, in the direction of deeper water, the Sponge Gravel loses its character. The sponges probably grew in a strong current, which caused them to require powerful attachments in order to maintain their position. When overthrown they would be swept into heaps like this along with an occasional ammonite, and with multitudes of attached shells, chiefly Brachiopoda, such as *Terebratula sella*, *Waldheimia tamarindus*, *Thecidium Faringdonense*, and others already named."

Professor Morris "could endorse much of what Mr. Meyer had advanced, especially as regards the Tourtia beds of Belgium, the fossils being representative of, rather than identical with those of the Faringdon Lower Greensand. There could no longer be any doubt as to the true position of the Faringdon Beds. Towards the south-east of England the trifold series of the Lower Greensand was complete, but in a north-westerly direction the beds are thinning out, the Upper Series alone being continued in this direction, and thus transgressive, as is usual in an area undergoing continuous depression. He concluded by noticing the great resemblance of this peculiar rock to the Coralline, or, more properly, Bryozoan Crag of Suffolk, pointing out also the number of derivative shells, and suggesting that during its deposition portions of the Wealden area might have been still unsubmerged."

The last place visited was Boutcher's, or the East pit—noteworthy fossils *Rhynchonella nuciformis*, *Trematopygus*, *Nautilus lævigatus* (?). The beds are composed chiefly of small pebbles mixed with ferruginous sand: the pebbles are mostly quartzose, with some lydites and green rock. There is less calcareous matter than in the other pit, and the upper part is less perforated by potholes: rounded masses of buff argillo-calcareous stone bored by a richly sculptured *Modiola* (?) are not unfrequent. The Sponge Gravel of the other pit may be seen in one corner at the base of this series.

The day's proceedings were brought to a close by a dinner at the Crown Hotel, in Faringdon, when the services of the Directors were duly acknowledged; after which the majority of the party returned to London, though a few remained behind with Professor Morris, for the purpose of further examining the Coral Rag and Lower Calcareous Grit of the district.

EXCURSION TO SANDGATE AND FOLKESTONE.

JUNE 19TH, 1876.

Director—F. G. HILTON PRICE, Esq., F.G.S., &c.

(*Report by* MR. HILTON PRICE.)

The party from London was met at the Shorncliffe Camp Station about 12 o'clock, by the Director and Dr. Charles Barrois, the eminent French Geologist of Lille.

The party proceeded at once along the Sandgate Road towards the shore, passing over the high ground above Sandgate, which is composed of the Folkestone-beds of the Upper Neocomian. No. 3 bed of Mr. Price's section, see paper on the "Lower Greensand and Gault of Folkstone," Proc. Geol. Assoc., Vol. iv., p. 139.

Arriving on the shore, the under-cliff was examined, where the junction between bed No. 3 and bed No. 2 were plainly seen, showing the calcareous gritty beds reposing on the dark-greenish "hassocky" beds of No. 2 and No. 1. Proceeding onwards towards the turnpike on the Lower Sandgate Road, the Members had the opportunity of inspecting the Sandgate-beds of the Upper Neocomian, coming on gradually and just below the turnpike, and of examining the base-bed of the Sandgate series (the *Rhynchonella sulcata* zone), all of which beds dip N.N.E., therefore as the party walked eastwards they gradually came upon higher formations. Many pieces of pyritized wood were collected in bed No. 1 of the Sandgate series. The whole of the upper cliff from Sandgate to Folkestone Harbour is chiefly composed of the Third Division of the Folkstone-beds of the Upper Neocomian, thus the Members had ample opportunities of seeing this fine section, with the Gault coming on just above the harbour. The Director pointed out the position of the "Elephant-bed," at the Battery, at the eastern corner of the West Cliff, none of which is now visible, it having been mostly dug out when the Battery was constructed. The party becoming fatigued after their walk in the hot sun, were very willing to partake of luncheon at the Pavilion Hotel.

After luncheon the Director conducted the Members to the end of the Pier, in order to show them the fine cliff section of the Upper Neocomian series, with the Gault capping it. After giving a short explanation of the section, they walked down to the shore through the harbour to examine all the Folkestone-beds of the Upper Neocomian, which are so well shown at this point. Owing to the continued prevalence of westerly winds, the greater portion of the Sandgate-beds were buried in sand; but only the upper part of bed No. 4 of that series was seen *in situ*. At low spring tides the whole of the Sandgate-beds may be seen near the harbour, together with the zone of *Rhynchonella sulcata* (bed No. 1.), which bed receives its name in consequence of the abundance of that species which it contains. The whole of the Folkestone-beds, however, were well examined, and a few explanations were offered by the Director upon these beds, which gradually dip away as we approach Copt Point. Many of the Members collected each a few fossils, and had the chagrin of seeing many fine specimens of *Exogyra* and *Pseudodiadema* on the rocks, which they were unable to obtain, owing to the hard nature of these beds and the feebleness of their instruments. He pointed out the various zones, and showed the position of the *Ammonites mammil-*

laris zone in the cliff, the Junction-bed, between the Upper Neocomian and the Gault, with the sulphur-band of the zone of *Ammonites interruptus* resting upon it.* As Copt Point is turned, these beds are lost beneath the sea level, and the beds of the Lower and Upper Gault, which form the cliff at this point, become more accessible.

In East Weir Bay, these beds are no longer *in situ* as they were seen at Copt Point, for, owing to frequent landslips they have all been thrown down, and form the floor of the sea shore. It being low-water at the time of our visit, the Members were able to examine the lithological and palæontological characters of the various zones, which were explained by the Director. Mr. John Griffiths, the well-known fossil collector of Folkestone, being engaged for the day, disclosed with his pickaxe the richness of the formation, and many typical fossils were collected by Members.

Having passed over the Gault, Mr. Hilton Price pointed out the junction between the Upper Gault and the so-called Upper Greensand, which rests conformably upon the Gault, with a few pipings of the dark-green marly sand passing down into the marly beds of the Upper Gault. This deposit is only about 14 feet in thickness here, and passes gradually into the Chalk Marl, the green grains continuing upwards for several feet—this formation is poor in organic remains. The Chalk Marl, on the contrary, is very fossiliferous, and is about 10 feet in thickness.

At this juncture the Members very reluctantly abandoned going on further, owing to want of time, and returned through the Warren to the South Eastern Railway Station, from which they proceeded to town by the evening train.

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* The position of the large *Plesiosaurus*, which was found by Mr. Griffiths in the cliff near Copt Point, in Bed II. of the Gault, was pointed out to the party.

EXCURSION TO BLACKHEATH AND CHARLTON.

July 1st, 1876.

Director.—Professor Morris, F.G.S.

Leaving Blackheath Station, the party walked across the heath to the south-east corner of the plateau, and at the edge of one of the gravel pits which expose its geological structure, gathered round the Director, who explained the geology of the district. After pointing out the characters of the pebbles composing the so-called "Oldhaven Beds" on which they stood (see Proc. Geol. Assoc., Vol. iv., p. 498), Professor Morris reminded his hearers that these great accumulations of shingle occupied a large area in Kent, forming several plateaux, as Blackheath, Lessness Heath, and Plumstead Common, as well as the hills of Shirley and much of the ground about Bromley and Chislehurst. The great fault running east and west along the south side of the Thames where the ground begins to rise from the alluvial flats, throws down the Lower Eocenes, and the Chalk, which is revealed above the river-level at Lewisham and Charlton, is perhaps two hundred feet below the surface of the flat land by the river, and probably correspondingly deeper below the higher land of the northern side of this part of the Thames Valley. The escarpment parallel with the fault is capped for the most part by the Pebble-beds, and is indented by small ravines cut by the water issuing at the junction of these porous beds with the argillaceous Woolwich Beds below. "Woodlands," a good example of these frequently well-wooded and picturesque dells, was visited *en route* to Charlton. The walk to the village of Charlton was enlivened by the legendary lore of Mr. C. White, a Member residing in the neighbourhood, who amusingly narrated the historical associations of this ancient village, and the great Jacobean Manor House which crowns with its stately facades and picturesque gables the highest ground. Descending the escarpment, the [illegible] the great Chalk pit so often visited by Memb[illegible]ciation. The section here has been [illegible]ges, and is described in det[illegible], Vol. iv., p. 528).

ORDINARY MEETING, JULY 7TH, 1876.

WILLIAM CARRUTHERS, Esq., F.R.S., President, in the Chair.

The following Donations were announced:—

"Abstracts of the Proceedings of the Geological Society," No. 320; from that Society.

"Journal of the Quekett Microscopical Club," No. 31; from that Club.

"Journal of the Society of Arts," June, 1876; from that Society.

"Transactions of the Manchester Geological Society," Vol. viii., Part 2; from that Society.

"Transactions of the Watford Natural History Society," Vol. i., Part 4; from that Society.

"Proceedings of the Berwickshire Naturalists' Club," Vol. vii., No. 3; from that Club.

"Proceedings of the Bristol Naturalists' Society," New Series, Vol. i., Part 3; from that Society.

"Annual Report of the Bristol Naturalists' Society for 1875;" from that Society.

"Fifth Annual Report of the United States Geological Survey" (Montana), for 1872; from Dr. T. V. Hayden.

"Final Report of the United States Geological Survey of Nebraska;" from Dr. T. V. Hayden.

"Bulletin of the United States Geological and Geographical Survey of the Territories," Vol. ii., No. 3; from Dr. T. V. Hayden.

"Contributions to the Extinct Vertebrate Fauna of the Western Territories" (U.S.A), by Joseph Leidy; from Dr. Hayden.

"A Selection of the Geological Memoirs contained in the 'Annales des Mines,' translated by H. T. De la Beche, F.R.S.;" from John Hopkinson, Esq., F.L.S.

"Reports of the Field Meetings of the Watford Natural History Society in 1875," by John Hopkinson, F.L.S., F.G.S.; from the Author.

"On the Origin of the Serpentine of the Ronda Mountains," by J. Macpherson; from the Author.

"The Physical Structure of the London Basin, considered in its Relation to the Geology of the Neighbou[illegible] by Professor John Morris, F.G.S.; from the [illegible]

"On the Chronology of Recent Geology," by S. R. Pattison, F.G.S.; from the Author.

"Sobre las Rocas Eruptivas de la Provincia de Cadiz," by Don J. Macpherson; from the Author.

The following were elected Members of the Association:—

James A. Agnew, Esq.; John Alstone, Esq.; Herbert Bamford, Esq.; Henry Letts, Esq.; Alexander Macpherson, Esq.; John E. Price, Fsq., F.S.A., Gerald Edward Tinson, Esq.; and Lewis J. May, Esq., M.R.C.S.

The following Papers were read:—

1. ON THE GEOLOGY OF BRIGHTON, Part II.

By JAMES HOWELL, Esq.

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2. ON THE BRITISH PALÆOZOIC ARCADÆ.

By J. LOGAN LOBLEY, Esq., F.G.S.

EXCURSION TO THE NORTH WALES BORDER.

MONDAY, JULY 17TH, AND FIVE FOLLOWING DAYS.

Directors—D. C. DAVIES, ESQ., F.G.S., PROFESSOR MORRIS, F.G.S., and HENRY HICKS, Esq., F.G.S.

(*Report by* MR. DAVIES.)

On MONDAY afternoon a short excursion was made to Cyrnybwch, two miles west of Oswestry, from whence a very fine and extensive view was obtained of the border counties. Here Professor Morris pointed out the difference in the character of the landscape to the west from that to the east. To the west were the rugged rocks of Silurian age, broken up and sculptured into numerous mountain groups, and on the east there was the gently undulating plain of the New Red Sandstone; just to the west was band of Carboniferous Limestone, which at this point appeared [illegible] very thin, but this was owing to the highly inclined position [illegible] strata. There was a difference in the manner in which the

Silurian and Carboniferous strata were deposited; the former by mechanical segregation, the latter chiefly by living organisms, which built up bed after bed, so that the deposit was literally an accumulation of organic remains. Mr. Davies pointed out local illustrations of what Professor Morris remarked. Pointing westward, he said there were the Arenig or Lower Llandeilo beds, which would be seen running in ridges east and west. Upon these strata rested on either side a succession of greenstone, felspathic and porphoritic rocks, which were interstratified with slates, shales, and limestones, all of which led up to the Bala Limestone, which was covered in its turn by shales and a limestone known as the Hirnant Limestone, all of which, with the overlying strata, would be seen during the week. Opposite the point where they stood, the Carboniferous Limestone rested immediately upon the Llandeilo and Arenig strata, so that there was here a great overlay and a geological gap between the two formations of many thousand feet of strata. Northward, however, as they would see, the various intermediate beds, Llandeilo, Bala, Llandovery, Wenlock, Old Red Sandstone—all succeeded in their proper place, so that at a point ten miles to the north, the whole series was nearly complete.

They would also observe the unconformability of the strata near the point on which they stood. The strike of the Silurian beds, as indicated by the mountainous ridges before them, was east and west. That of the Carboniferous Limestone, the Millstone Grit, and the Coal Measures, north and south, or just at right angles one to the other. Away in the distance to the south-east, they would see the long ridges of the Longmynd, which were made up of Cambrian strata. Those beds dipped westward, and following the various undulations of the strata, passed under our feet, and came up in the Merionethshire anticlinal, from Barmouth and Harlech northward, and further west still in the Cambrian rocks of Caernarvonshire. Nearer still than the Longmynd, was the ridge of the Stiperstones, which, with its associated beds, they also saw in the Breidden range of hills, and more largely developed in the hard ridges of greenstone porphyry, with their interstratified beds which were spread out to the west. In the smoke to the south they would see the southern termination of the belt of Coal Measures which extended along the Border to the estuary of the Dee. Of the Millstone Grit on which they stood, he would have another opportunity of speaking, and he would conclude by pointing out the ridge of Grinshill and Hawkstone on the south, and that of Peckforton on the north. These two ridges were the outcrops of that basin or trough of Keuper Sandstones, in which lay the great salt deposits of this country. The party then proceeded to collect fossils from the Millstone Grit, among which they found *Streptorhyncus crenistria*, *Athyris ambigua*, *Spirifera striata*, *Productus semireticulatus*, a large coral allied to *Clisiophyllum*, a smaller species resembling the *Petraia* of the older rocks, and a fragment or two of *Trilobites*. The party then proceeded to notice the junction between the Carboniferous Limestone and the Millstone Grit, which is well shown on Offa's Dyke, after which they returned to Oswestry.

On TUESDAY morning the party assembled at Pontfaen, a romantic spot on the river Ceiriog, near Chirk, from which they proceeded by the Glyn Valley Tramway to Pontdolwern. A walk of about a mile, enlivened by various flying discussions relating to the order and grouping of the Llandovery, Tarannon and Wenlock strata of the district, brought them to Nant Iorwith, where there is an old quarry in the lower beds of the Bala Limestone. A halt was made here while Mr. Davies explained the geological structure of the locality. He said that two miles to the south of them, a band of greenstone surmounted a thick mass of dark shaly and slaty rocks, in the upper part of which there were also frequently thin bands of metamorphic rock. This greenstone he took to be the base of the Llandeilo strata of the district, the beds below belonging, as he thought, to the Arenig group. Above this greenstone, and dipping north, or towards where they stood, there was a thick deposit of black shales, with occasional bands of hard rock. This was surmounted by a thick deposit of stratified porphorytic rocks as seen at Pontymeibion and Llechryddau. The beds of this group were very varied, and some were beautiful, consisting of angular fragments of red felspar, cemented in green, cream-coloured, and white paste. This porphorytic group was overlaid by a thick mass of dark shales, which in their turn were capped by a band of felspathic rock, the upper bed of which was very pure, and was quarried in the neighbourhood for the manufacture of china. Above this felspathic band was a band of dark limestone, not marked on the maps, which he took to be the equivalent in North Wales of the Llandeilo Limestone of the South. This limestone was rich in fossils. He thought it corresponded to the limestone *laris* zone in the cliff, the Junction-bed, between the Upper Neocomian and the Gault, with the sulphur-band of the zone of *Ammonites interruptus* resting upon it.* As Copt Point is turned, these beds are lost beneath the sea level, and the beds of the Lower and Upper Gault, which form the cliff at this point, become more accessible.

In East Weir Bay, these beds are no longer *in situ* as they were seen at Copt Point, for, owing to frequent landslips they have all been thrown down, and form the floor of the sea shore. It being low-water at the time of our visit, the Members were able to examine the lithological and palæontological characters of the various zones, which were explained by the Director. Mr. John Griffiths, the well-known fossil collector of Folkestone, being engaged for the day, disclosed with his pickaxe the richness of the formation, and many typical fossils were collected by Members.

Having passed over the Gault, Mr. Hilton Price pointed out the junction between the Upper Gault and the so-called Upper Greensand, which rests conformably upon the Gault, with a few pipings of the dark-green marly sand passing down into the marly beds of the Upper Gault. This deposit is only about 14 feet in thickness here, and passes gradually into the Chalk Marl, the green grains continuing upwards for several feet—this formation is poor in organic remains. The Chalk Marl, on the contrary, is very fossiliferous, and is about 10 feet in thickness.

At this juncture the Members very reluctantly abandoned going on further, owing to want of time, and returned through the Warren to the South Eastern Railway Station, from which they proceeded to town by the evening train.

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* The position of the large *Plesiosaurus*, which was found by Mr. Griffiths in the cliff near Copt Point, in Bed II. of the Gault, was pointed out to the party.

EXCURSION TO BLACKHEATH AND CHARLTON.

JULY 1ST, 1876.

Director.—Professor MORRIS, F.G.S.

Leaving Blackheath Station, the party walked across the heath to the south-east corner of the plateau, and at the edge of one of the gravel pits which expose its geological structure, gathered round the Director, who explained the geology of the district. After pointing out the characters of the pebbles composing the so-called "Oldhaven Beds" on which they stood (see Proc. Geol. Assoc., Vol. iv., p. 498), Professor Morris reminded his hearers that these great accumulations of shingle occupied a large area in Kent, forming several plateaux, as Blackheath, Lessness Heath, and Plumstead Common, as well as the hills of Shirley and much of the ground about Bromley and Chislehurst. The great fault running east and west along the south side of the Thames where the ground begins to rise from the alluvial flats, throws down the Lower Eocenes, and the Chalk, which is revealed above the river-level at Lewisham and Charlton, is perhaps two hundred feet below the surface of the flat land by the river, and probably correspondingly deeper below the higher land of the northern side of this part of the Thames Valley. The escarpment parallel with the fault is capped for the most part by the Pebble-beds, and is indented by small ravines cut by the water issuing at the junction of these porous beds with the argillaceous Woolwich Beds below. "Woodlands," a good example of these frequently well-wooded and picturesque dells, was visited *en route* to Charlton. The walk to the village of Charlton was enlivened by the legendary lore of Mr. C. White, a Member residing in the neighbourhood, who amusingly narrated the historical associations of this ancient village, and the great Jacobean Manor House which crowns with its stately facades and picturesque gables the highest ground. Descending the escarpment, the party entered the great Chalk pit so often visited by Members of the Geologists' Association. The section here has been frequently mentioned in these pages, and is described in detail in the present volume (Proc. Geol. Assoc., Vol. iv., p. 528).

ORDINARY MEETING, July 7th, 1876.

William Carruthers, Esq., F.R.S., President, in the Chair.

The following Donations were announced:—

"Abstracts of the Proceedings of the Geological Society," No. 320; from that Society.

"Journal of the Quekett Microscopical Club," No. 31; from that Club.

"Journal of the Society of Arts," June, 1876; from that Society.

"Transactions of the Manchester Geological Society," Vol. viii., Part 2; from that Society.

"Transactions of the Watford Natural History Society," Vol. i., Part 4; from that Society.

"Proceedings of the Berwickshire Naturalists' Club," Vol. vii., No. 3; from that Club.

"Proceedings of the Bristol Naturalists' Society," New Series, Vol. i., Part 3; from that Society.

"Annual Report of the Bristol Naturalists' Society for 1875;" from that Society.

"Fifth Annual Report of the United States Geological Survey" (Montana), for 1872; from Dr. T. V. Hayden.

"Final Report of the United States Geological Survey of Nebraska;" from Dr. T. V. Hayden.

"Bulletin of the United States Geological and Geographical Survey of the Territories," Vol. ii., No. 3; from Dr. T. V. Hayden.

"Contributions to the Extinct Vertebrate Fauna of the Western Territories" (U.S.A.), by Joseph Leidy; from Dr. Hayden.

"A Selection of the Geological Memoirs contained in the 'Annales des Mines,' translated by H. T. De la Beche, F.R.S.;" from John Hopkinson, Esq., F.L.S.

"Reports of the Field Meetings of the Watford Natural History Society in 1875," by John Hopkinson, F.L.S., F.G.S.; from the Author.

"On the Origin of the Serpentine of the Ronda Mountains," by J. Macpherson; from the Author.

"The Physical Structure of the London Basin, considered in its Relation to the Geology of the Neighbourhood of Watford," by Professor John Morris, F.G.S.; from the Author.

"On the Chronology of Recent Geology," by S. R. Pattison, F.G.S.; from the Author.

"Sobre las Rocas Eruptivas de la Provincia de Cadiz," by Don J. Macpherson; from the Author.

The following were elected Members of the Association:—

James A. Agnew, Esq.; John Alstone, Esq.; Herbert Bamford, Esq.; Henry Letts, Esq.; Alexander Macpherson, Esq.; John E. Price, Fsq., F.S.A., Gerald Edward Tinson, Esq.; and Lewis J. May, Esq., M.R.C.S.

The following Papers were read:—

1. On the Geology of Brighton, Part II.

By James Howell, Esq.

2. On the British Palæozoic Arcadæ.

By J. Logan Lobley, Esq., F.G.S.

EXCURSION TO THE NORTH WALES BORDER.

Monday, July 17th, and Five Following Days.

Directors—D. C. Davies, Esq., F.G.S., Professor Morris, F.G.S., and Henry Hicks, Esq., F.G.S.

(*Report by* Mr. Davies.)

On Monday afternoon a short excursion was made to Cyrnybwch, two miles west of Oswestry, from whence a very fine and extensive view was obtained of the border counties. Here Professor Morris pointed out the difference in the character of the landscape to the west from that to the east. To the west were the rugged rocks of Silurian age, broken up and sculptured into numerous mountain groups, and on the east there was the gently undulating plain of the New Red Sandstone; just to the west was a band of Carboniferous Limestone, which at this point appeared to be very thin, but this was owing to the highly inclined position of the strata. There was a difference in the manner in which the

Silurian and Carboniferous strata were deposited; the former by mechanical segregation, the latter chiefly by living organisms, which built up bed after bed, so that the deposit was literally an accumulation of organic remains. Mr. Davies pointed out local illustrations of what Professor Morris remarked. Pointing westward, he said there were the Arenig or Lower Llandeilo beds, which would be seen running in ridges east and west. Upon these strata rested on either side a succession of greenstone, felspathic and porphoritic rocks, which were interstratified with slates, shales, and limestones, all of which led up to the Bala Limestone, which was covered in its turn by shales and a limestone known as the Hirnant Limestone, all of which, with the overlying strata, would be seen during the week. Opposite the point where they stood, the Carboniferous Limestone rested immediately upon the Llandeilo and Arenig strata, so that there was here a great overlay and a geological gap between the two formations of many thousand feet of strata. Northward, however, as they would see, the various intermediate beds, Llandeilo, Bala, Llandovery, Wenlock, Old Red Sandstone—all succeeded in their proper place, so that at a point ten miles to the north, the whole series was nearly complete.

They would also observe the unconformability of the strata near the point on which they stood. The strike of the Silurian beds, as indicated by the mountainous ridges before them, was east and west. That of the Carboniferous Limestone, the Millstone Grit, and the Coal Measures, north and south, or just at right angles one to the other. Away in the distance to the south-east, they would see the long ridges of the Longmynd, which were made up of Cambrian strata. Those beds dipped westward, and following the various undulations of the strata, passed under our feet, and came up in the Merionethshire anticlinal, from Barmouth and Harlech northward, and further west still in the Cambrian rocks of Caernarvonshire. Nearer still than the Longmynd, was the ridge of the Stiperstones, which, with its associated beds, they also saw in the Breidden range of hills, and more largely developed in the hard ridges of greenstone porphyry, with their interstratified beds which were spread out to the west. In the smoke to the south they would see the southern termination of the belt of Coal Measures which extended along the Border to the estuary of the Dee. Of the Millstone Grit on which they stood, he would have another opportunity of speaking, and he would conclude by pointing out the ridge of Grinshill and Hawkstone on the south, and that of Peckforton on the north. These two ridges were the outcrops of that basin or trough of Keuper Sandstones, in which lay the great salt deposits of this country. The party then proceeded to collect fossils from the Millstone Grit, among which they found *Streptorhyncus crenistria*, *Athyris ambigua*, *Spirifera striata*, *Productus semireticulatus*, a large coral allied to *Clisiophyllum*, a smaller species resembling the *Petraia* of the older rocks, and a fragment or two of *Trilobites*. The party then proceeded to notice the junction between the Carboniferous Limestone and the Millstone Grit, which is well shown on Offa's Dyke, after which they returned to Oswestry.

On TUESDAY morning the party assembled at Pontfaen, a romantic spot on the river Ceiriog, near Chirk, from which they proceeded by the Glyn Valley Tramway to Pontdolwern. A walk of about a mile, enlivened by various flying discussions relating to the order and grouping of the Llandovery, Tarannon and Wenlock strata of the district, brought them to Nant Iorwith, where there is an old quarry in the lower beds of the Bala Limestone. A halt was made here while Mr. Davies explained the geological structure of the locality. He said that two miles to the south of them, a band of greenstone surmounted a thick mass of dark shaly and slaty rocks, in the upper part of which there were also frequently thin bands of metamorphic rock. This greenstone he took to be the base of the Llandeilo strata of the district, the beds below belonging, as he thought, to the Arenig group. Above this greenstone, and dipping north, or towards where they stood, there was a thick deposit of black shales, with occasional bands of hard rock. This was surmounted by a thick deposit of stratified porphorytic rocks as seen at Pontymeibion and Llechryddau. The beds of this group were very varied, and some were beautiful, consisting of angular fragments of red felspar, cemented in green, cream-coloured, and white paste. This porphorytic group was overlaid by a thick mass of dark shales, which in their turn were capped by a band of felspathic rock, the upper bed of which was very pure, and was quarried in the neighbourhood for the manufacture of china. Above this felspathic band was a band of dark limestone, not marked on the maps, which he took to be the equivalent in North Wales of the Llandeilo Limestone of the South. This limestone was rich in fossils. He thought it corresponded to the limestone at Craig y Glyn, eight miles to the S.W. on the other side of the anticlinal he spoke of yesterday. Then came more shales, followed by a thin ash bed, known as "The Bala Ash," which might fairly be taken as the boundary between the Llandeilo rocks below and the Bala or Caradoc group above. They could see this ash bed close to where they stood, and would observe that it did not lie far below the Bala Limestone. They would soon find how rich this limestone was in fossils. The lower beds, as they saw, were massive, but in a quarry higher up in the series, to be visited presently, the beds were much thinner, and were interstratified with shales. In those higher beds the prevailing corals *Halysites* and *Heliolites* appeared in plenty. The limestone was about 300 feet thick, and it was not nearly so fragmentary and inconstant as it had sometimes been represented to be. Above the Limestone lay some fossiliferous pale shales, and then came the Hirnant Limestone, so called because it was observed first in the valley of the Hirnant, near Bala. This limestone he took as the summit of the Bala Group. Above it came the Llandovery Beds, which lay before them to the north-east, and which were surmounted by the hills of Wenlock Shale on the other side of the valley. The Llandovery beds thickened greatly in their progress to the north-west towards Corwen, so that at this point they were present only in an attenuated form. The Wenlock beds would be visited another day.

Dr. Hicks then made some remarks concerning the mode of the deposition of the groups of strata described. He said he would be glad to know whether the strata absent at this point belonged to the lower or upper beds of the Llandovery group, and whether the gap lay between the Llandovery beds and the Tarannon Shale, or between the latter and the Wenlock beds. It was also a question whether the Tarannon beds were most nearly allied to the Wenlock or to the Llandovery. He could hardly agree with the unconformability described, and suggested that the absence of several of the beds might be due to a fault.

Mr. Davies, in reply, said that he had considered whether the absence of many of the Llandovery beds might be due to a fault, but he failed to see how that could account for the fact of the gradual thickening of the beds northward, and the disappearance one by one of the underlying beds southward, until, as pointed out yesterday, west of Cyrnybwch, the Carboniferous Limestone lay directly upon Lower Llandeilo or Arenig strata. It was the upper members of the Llandovery beds that were absent there, and northward they appeared one by one from underneath the Tarannon Shale. Though the gap at this point lay between the Tarannon Shale and the Llandovery beds, yet he regarded the former as being more allied to the latter group than to the Wenlock Shale.

Professor Morris spoke of the importance of the questions they were discussing, and the grandeur of the geological phenomena implied in massing together the groups of strata just described. The only way of arriving at a satisfactory solution of many geological problems was by careful local investigation, associated with a broad correlation of similar phenomena over a large area.

The search for fossils then began, and was rewarded by many specimens of *Lingula longissima, Orthis calligramma, O. elegantula, O. Actonia, O. porcata, Strophomena depressa, Theca, Bellerophon, Lituites, Asaphus Powisii, Phacops, Trinucleus*, and other well-known fossils of the Bala Limestone.

The party then ascended to Cefn-y-Coed quarry, where some good examples of *Halysites catenularis* were obtained. A scramble over the edges of the overlying shales led to the Hirnant Limestone, some of the beds of which were a mass of fragments of organic remains. A start was then made for the New Inn, Glyn Ceiriog, where luncheon had been hospitably provided by a Member of the Association, Mr. John Jones, F.R.G.S., who is the owner of property in the valley.

Afterwards most of the party walked up the valley to its junction with that of the Deirw, where a good view was obtained of the felspathic and porphoritic rocks, which had been described in the morning.

On WEDNESDAY the first point of interest visited was a quarry in the Carboniferous Limestone, at Dolcoch, three miles south of Oswestry. From this a good view of the whole series of limestones could be seen. Mr. Davies said the party then stood within three miles of the southern termination of the band of Carboniferous Limestone, which runs along the North Wales Border. He described it as consisting in ascending order of first a series of pale-coloured beds, much quarried for fluxing stone; secondly, a series of thin grey beds which, in that neighbourhood, passed into a reddish impure limestone used for mending roads; and, thirdly, a succession of grey limestones and shales abounding in corals, *Productus, Spirifera*, and the usual fossils, and noted in this neighbourhood for occasional large specimens of *Orthoceratites* and *Nautilus*. The quarry they were in was in the middle portion of these upper beds, and he had no doubt many fossils would be found. Professor Morris described the characteristics of the genus Productus, the most abundant group of shells in the Limestone, and stated that Dr. Chas. Barrois, who was present, was much struck with the resemblance of the Limestone to that of Vesey, in Belgium. Among the fossils found were *Strophomena analoga, Productus latissimus, P. giganteus, P. Youngianus, Chonetes Hardrensis, Streptorhyncus crenistria* with its variety *senilis, Athyris Roysii, Rhynconella pugnus, R. pleurodon, Orthis resupinata, O. Michelini* with *Lithostrotion irregulare*, and other corals, also several specimens of Conchifera, not determined. The position of the corals and shells *in situ* in the beds was also noticed, showing how their remains constituted the greater part of some of the layers of limestone.

After luncheon, kindly provided in the Summer-house by Mr. Stanley Leighton, M.P., a visit was made to a quarry in the Millstone Grit, close by. After numerous specimens of *Productus semireticulatus* had been obtained from one of the upper sandstone beds where they lay in shoals. Mr. Davies gave a brief description of the Millstone Grit of the district. He described it as about 300 feet thick. It consists of a series of red and yellow sandstones at the base. These are often coarse and pebbly in structure; but they contain numerous fossils, including the Permian shell *Schizodus*. In the middle portion there were some calcareous sandstones, which, in their progress northwards, become decided limestones, and were quarried near Mold for agricultural lime. The upper portion, in which the quarry was situated, consisted of massive beds of white and buff-coloured sandstones, with coarse pebbly beds, and thin clay and iron stones. It was from this quarry, and from the bed from which the shells had just been obtained, that a large *Orthoceratite*, about 6ft. long, and 1ft. 6in. in diameter at the largest end, had been obtained. That specimen was now in the Derby Museum, Liverpool. He regarded the beds from the calcareous bands downwards to, and, perhaps, inclusive of the uppermost Carboniferous Limestones and shales, as the equivalent of the Yoredale Series of the North of England. Above the middle limestones was the true Millstone Grit. Although the Coal Measures came in just outside the quarry, these were not the highest beds of the formation. Those seen on Monday afternoon were higher, and the sandstones at Trevor, near Llangollen were higher still. Associated with the shells in the quarry were stems of *Calamites*, and fragments of other Coal Measure plants, which were the heralds of the more abundant flora of which the Coal beds were formed. He directed attention to the curious "pockets" which occurred in the solid sandstone on all sides of the quarry, and would like to hear Professor Morris' explanation of them.

Professor Morris said the material of the pockets was, he believed, made up of iron and manganese, mixed with loose sand. There was an absence in the pockets of the felspar, which was the cementing matrix of the sandstone. It had been observed that there was a tendency in minerals to segregate around a common base, and instanced some mines in Spain where the same tendency was observed among the metallic refuse.

The middle calcareous beds were then visited, at which point the party got unintentionally separated. One section made for some old quarries at Wern, where many corals were found. These included *Lithostrotion irregulare, L. junceun, L. minor, L. floriforme, L. Martini, L. major, Phillipsastrea radiata,* and *P. tuberosa.* The other section went by the quarries at Treflach, where they found *Zaphrentis cylindrica, Syringopora ramulosa, S. gemiculata,* and *Alveolites septosa,* in addition to some of the corals enumerated above. A large party proceeded to the hill Moelydd, from which a grand panoramic view of the mountains of North Wales, as well as of the Shropshire and Cheshire plains was obtained. Professor Morris gave an address on the geographical features of the landscape, in which he pointed out the difference between the conical Silurian hills, and the battlemented ridges of Limestone, whose escarpments were so well seen from where they stood. He noticed how the edges of the limestone beds abutted below their feet against the greenstone boss which forms the western face of the hill, whose true place was thousands of feet below them. He also pointed out how the beautiful crystals of sulphide of iron the rock contained, indicated the presence of vegetation in the early sea in which it was formed. In the comparative level of the plains to the east they saw the greater freedom from disturbances which characterized the newer deposits.

Few of those who were present will forget either the scene or the address.

On THURSDAY the party proceeded by rail to Llanderfel Station. After refreshments, thoughtfully prepared by Mr. Ruddy, had been disposed of, and an inspection of an interesting series of fossils, collected by that gentleman, a quarry in the Wenlock Shale at Bryn Sylwrn, was visited. Here *Diplograpsus pristis* and *Retiolites Geinitzianus* (the latter a rare form), were found, also beautifully preserved specimens of the internal tubes of *Orthoceras primævum*, with *Athyris marginalis.* Professor M'Kenny Hughes, who had joined the party that day, pointed out the striation of the rock surface; and the difference between cleavage, joints, and bedding. He showed how the beds of the quarry rested upon the Tarannon Shale close by, and how, with their overlying grits, and uppermost slates, they dipped under the Berwyns, and rose again on the other side.

The ascent of the Berwyn Mountains was then made. Professor Peters, F.G.S., of Bala, pointed out objects of local interest, and halts were made to admire the scenery, which embraced most of the Welsh mountain ranges. Before descending to Llangynog, a visit was paid to a mine worked in the Phosphate Bed of the Bala Limestone. Mr. Davies described the position of this bed, as being at the top of the Bala Limestone, which there was about 300ft. thick. The bed varied from 9 to 18 inches in thickness, it was nodular in form, and some of the nodules still preserved their organic structure. The question had been raised: was the bed deposited pure and simple from the phosphoric acid diffused through the water, or was it first taken up into organic life and then deposited? The latter, he thought, was the true theory, where the mineral occurred, as it did in Wales, in wide spread beds. Most of the party went into the mine, and saw the bed; some of the more adventurous followed it through all the workings. *Orthis spiriferoides,* and other fossils, were obtained from one of the beds of the Bala Limestone, and then the party made the best of their way down the valley of the Rhiwarth, to the New Inn, to Llangynog, where luncheon had been amply provided by a Member of the Association, Mr. John Dovaston, of the Nursery, West Felton. Thanks to Mr. Dovaston were feelingly proposed by Professor Morris. In the unavoidable absence of Mr. Dovaston, Mr. Davies replied for him, and added that they were glad that while the name was already associated with the legendary lore of the district, it would also become connected with the local scientific explorations. After dinner the Members assembled under the Rhiwarth slate quarry, where, by the kindness of Mr. George Savin, and Mr. Roberts, the manager, much interesting information was obtained.

By the aid of a large section, Mr. Davies explained the structure of the Berwyn Hills, and the country generally, lying between Llanfyllin and Dinas Mawddwy, and he pointed out the correspondence stratigraphically of the Llangynog slate rocks with those of the Ffestiniog district. He also took the opportunity, in the presence of the Woodwardian Professor of Cambridge, to pay a tribute of respect to the memory of the late Professor Sedgwick, who was the first to unravel the intricate geology of North Wales. It gave him joy, he said, standing in the midst of the rocks, among which Sedgwick had laboured, to be surrounded both by older and younger geologists, who believed in the true classification and philosophical teaching of that great master of the science. Professor Hughes thanked Mr. Davies for the kind and true words he had spoken of his predecessor, and went on to describe very graphically the way in which the mountains and valleys had been sculptured into their present form by the streams wearing back the ends of the cwms or vallies. Dr. Hicks described the strata lying below those given in Mr. Davies's section, the Menevian and Upper Cambrian groups with the many remains of former life which had latterly been discovered in them, and after a few concluding words from Professor Morris, the party started for Oswestry, stopping by the way to notice the curved strata near the Bowling Green at Llangedwyn. Oswestry was reached at ten o'clock.

On Friday morning the district of Trevor and Llangollen were visited. The first point of interest was the brick-works of Mr. C. Mason, which lie on the junction of the Millstone Grit with the Coal Measures. The various beds were described, and their relation to similar beds in Lancashire and Yorkshire was pointed out. The party was then led by Mr. Mason to a new railway cutting, in which a good section of the Chwarele coal and clay was exposed: some interesting plant remains were observed on the sandstones. The Garth limestone quarries were next reached, and a halt made, in which there was a successful search for fossils, several groups of which were described by Professor Morris. A hot walk brought the party to the bold ridge of the Eglwyseg rocks, near Tan-y-Castell, where many good specimens of the fossil shell *Productus Llangollensis* were obtained. At this point Professor Hughes and Dr. Hicks left the party, some of whom prolonged their walk to Valle Crucis Abbey, and the rest walked leisurely to Llangollen. Mr. and Mrs. James Barnes had previously invited the Members of the Association and their friends to dine at Brookside House on this evening. About twenty-two assembled there, and sat down to a sumptuous dinner, elegantly served. In returning thanks to Mr. and Mrs. Barnes, Professor Morris spoke of the very great kindness and respect they had shown to the Association, which had never been so hospitably entertained as it had been during the visit to the North Wales Border. Mr. J. R. Barnes spoke of the pleasure it had been to Mrs. Barnes and himself to welcome them. Votes of thanks were then accorded to the Directors of the excursion and to the Secretary, and a long and successful day was brought to a close.

On Saturday morning several of the Members again enjoyed the hospitality of Mr. Doveston, at the Nursery; and the week's proceedings, which had been favoured with bright weather, terminated.

THE BAGSHOT SANDS IN THE ISLE OF SHEPPEY.

By MAJOR F. DUNCAN, D.C.L., L.L.D., F.G.S., &c.

(*Abstract.*)

Paper read March 3rd, 1876.

After referring to Prof. Prestwich's statement that natural sections of the Bagshot Sands are extremely rare, the author stated the occurrence of a road-section in the village of Minster of beds of sand reposing upon London Clay, which he considered, in accordance with the opinion of Prof. Prestwich and Prof. McKenny Hughes, to be an exposure of Bagshot Sands. The sands are of a light yellow colour, in some places passing into a "rusty yellow," as described by Mr. Whitaker; while the presence of clayey matter and the absence of fossils completes the resemblance between the beds here exposed and those in other places generally acknowledged to be of Lower Bagshot age. Though the section has a maximum depth of twelve feet, these beds must attain at this place a thickness of eighteen feet. The line of demarcation between the sands and the London Clay below is remarkably distinct, no passage-bed of an intermediate colour or lithological character separating the sand from the clay. From this distinctness of separation and the absence of fossils the author drew the inference that the sands were accumulated by atmospheric not aqueous agency—were, in fact, blown sands, and not sedementary deposits as has been usually supposed.

The circumstance that in some districts the Bagshot Sands are fossiliferous, and in others devoid of fossils, may be explained on the above theory, viz.: that in the former case the deposits have been sub-aqueous, in the latter sub-aerial.

ON THE MILL HILL CUTTING, SHEPPEY.

By W. H. SHRUBSOLE, Esq.

(*Abstract.*)

Paper read March 3rd, 1876.

At a depth of from six to eight inches below the surface of the road running through the village of Minster, and imbedded in gravel overlying the sand described by Major Duncan in the previous paper, an irregular and interrupted line of angular rock fragments was revealed by the cutting, and many other such fragments were found and buried by the workmen before the author's visit. The stones were identified by Mr. J. W. Judd as follows:—Carboniferous Limestone (probably many specimens), granite (hornblendic), quartz, dolerite, greenstone, diorite (with veins of quartzite felsite), granite (protogene), porphyrite (with quartz veins), and gabbro. Were these fragments the débris of blocks used for building purposes, or were they brought to Sheppey as ballast of ships, or, thirdly, had they been dropped from melting icebergs which had brought them from some northern region at the close of the Glacial Epoch? The last of these hypotheses was favoured by the author, who had been unable to find any ancient building in Sheppey in the construction of which igneous rock had been used, and who considered the distance from the harbour, the unusual material, and the non-commercial character of Sheppey in past times, fatal to the supposition that this accumulation of stones had been brought from abroad by ships.

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